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# HYDROTEST FOR FLTSATCOM

## FINAL REPORT


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A.F. ROCKET PROPULSION LABORATORY

AUGUST 1977

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On 7 April 1977 AFRPL conducted a hydrostatic burst test of a fired TE-M-364-19 motor case. During testing the case was constrained such that firing conditions were simulated. This test-to-failure demonstrated that the case had a safety factor in excess of the 1.25 minimum.


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## PREFACE

This technical report summarizes the work which culminated in the 7 April 1977 AFRPL In-House hydrostatic burst test of a TE-M-364-19 motor case. No previous technical reports have been published on this program. The author wishes to acknowledge those people who proved invaluable in conducting this test at the AFRPL. Mr. H. C. Butera was responsible for the design of the AFRPL fabricated test apparatus. 1Lt Joseph Hildreth consulted on the design. Mr. Attilio Bassoni was test engineer and coordinated all activities at the test area. Significant managerial guidance was provided by Mr. Donald Wian. Technical support and test particular hardware supplied by Mr. James Pletz of the Thiokol Corporation/Elkton Division and Mr. George Zaiser of the Defense and Space Systems Group of TRW, Inc., made a significant contribution to the success of this program.

## SUMMARY

To obtain more energy, the FLTSATCOM SPO is contemplating adding more propellant to the TE-M-364-19 apogee kick motor, depicted in Figure 1. This in turn would raise the MEOP of the motor. The increased MEOP would reduce the safety factor, thus necessitating a test to determine if an adequate safety factor existed. To demonstrate the required 1.25 safety factor, the case had to withstand an internal pressure of 942 psi concurrent with an applied external axial load of 20,000 $lb_f$.

On 7 April 1977, the AFRPL successfully conducted a hydrostatic burst test of a fired TE-M-364-19 motor case. A titanium flight attach ring, provided by TRW, FLTSATCOM prime contractor, was used to attach the motor to the test stand. This allowed the motor to expand under test pressurization in much the same manner as it would during an actual firing. The case failed at an internal pressure of approximately 1000 psig with an applied external axial load of approximately 20,615 $lb_f$. The case demonstrated a safety

factor greater than 1.3, well in excess of the minimum acceptable safety factor of 1.25. This technical report summarizes how this task was accomplished.

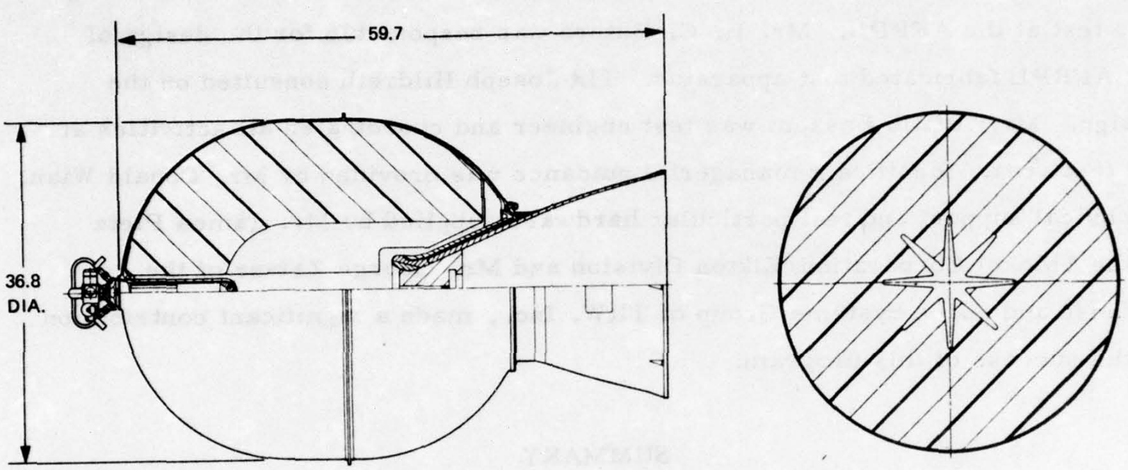


Figure 1. TE-M-364-19 Apogee Kick Motor for FLTSATCOM

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## HYDROTEST FOR FLTSATCOM

### INTRODUCTION

To adequately simulate the forces a motor is subjected to during launch, it was necessary to apply internal chamber (case) pressure and external axial load while constraining the motor in such a way that its growth would be similar to that experienced during an actual firing. The internal pressure a motor is subjected to during firing was simulated by pumping water into the sealed case. The thrust load due to acceleration during firing was simulated by using a hydraulic ram to apply an external axial force against the aft closure. A flightweight titanium flight attach ring was used to attach the motor to the test stand. This piece of flight hardware constrained the motor's growth much as it would during an actual launch.

A diaphragm type hydrostatic pump was used to pressurize the motor case. The pump was driven by $GN_2$ at a constant back pressure of 150 psi. No $GN_2$ was injected into the case by the pump. Before beginning pressurization, the case was filled with water, removing all trapped air.

A hydraulic ram was used to apply an external axial force against the aft closure of the case. The ram was actuated by a piston type hand pump. A certain amount of increased external axial loading was induced during pressurization as the case attempted to expand downward against the hydraulic ram. This condition became more pronounced as case pressure increased, as can be seen in Figure B-9. The ram system contained a relief valve which tended to minimize this effect at loads above 16, 000 $lb_f$. Ideally, the external axial load was to be maintained at 20, 000 $lb_f$ during the final stage of case pressurization leading to burst, as shown in Figure 2.

### PREPARATION AND TESTING

The motor case was prepared for testing according to procedures in Appendix A. Set-up was accomplished over a period of several days. Significantly, the motor case was filled with water approximately 24 hours before the test. This measure allowed sufficient time for case insulation to become saturated so

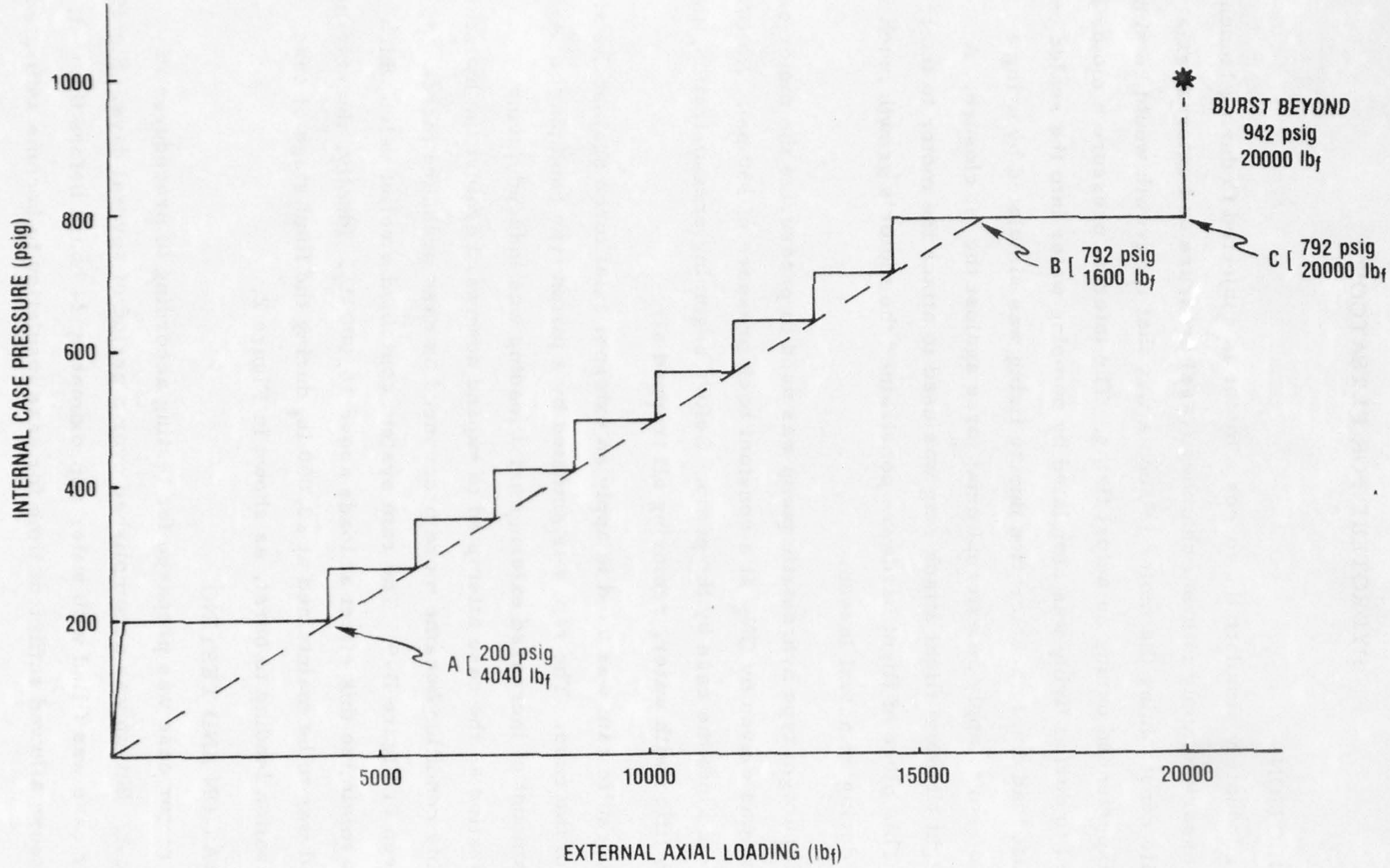


Figure 2. Loading Curve for TE-M-364-19 AKM Case

it could not absorb water during the test and thus invalidate volumetric computation. Once the "Z" cal of the Test Procedure, Appendix A, was performed, it took approximately 30 minutes to fail the case.

Case pressure and external axial load were applied in stair-step increments, as shown in Figure 2, until reaching 1.05 mean effective operating pressure (MEOP). It was determined that simultaneous application of axial force and increasing case pressure were not necessary during this portion of the test.

The hydrostatic pump, used for case pressurization, and the technician who operated the pump were located in a protected area immediately adjacent to the motor case. A Heise gage leading from the igniter closure gave the pump technician a continuous reading of case pressure. The project engineer received a direct readout from one of the pressure transducers mounted on the igniter closure and passed this data over the voice line to the pump technician. If there were a discrepancy between the two readings, the pressure transducer reading was considered the more accurate. During the pressurization portion of the initial stair-step, the case's volumetric rate of change was approximately 0.6 gal/min. In the final pressurization step leading to burst, the pump continuously delivered its maximum output of approximately 1.1 gal/min, (see Figure B-1).

The hand pump for the hydraulic ram and the technician who operated it were located in a protected area immediately adjacent to the motor case. A Heise gage connected to the hand pump gave the ram technician a constant reading of ram pressure, which he could translate into ram force. The project engineer received a direct readout from the hydraulic ram load cell and passed this data over the voice line to the ram technician. If there were a discrepancy between the two readings, the load cell reading was considered the more accurate. During the final stage of case pressurization leading up to burst, the relief valve was unable to keep pace with the increased force caused by case expansion as its yielding moved into the plastic region. At burst the external axial load was approximately 3 percent above the desired value, Figure B-9.

Volumetric change during pressurization was determined from the mass of water pumped into the case. A continuous reading was made of the weight of the storage tank from which water was pumped to pressurize the case. From this reading the mass of water which had been pumped into the case at any time could be determined. Using a constant conversion factor of 8.333 lbm/gal the volumetric change was calculated. This assumed that the water already in the case was the same temperature as the water in the storage tank and the water in the storage tank remained at a constant temperature. The maximum error associated with using the average temperature, $64^{o}F$, as the constant temperature of water in the storage tank was less than 0.03 percent, and the maximum error associated with assuming water to be incompressible was less than 0.3 percent. No provisions were made for determining the temperature of water in the case. Ambient air temperature at the time of the test was $82^{o}F$.

Data from the water storage tank load cell did not give readings as consistently as expected. Data points were somewhat erratic. This problem was probably due primarily to pump surge. In order to obtain more meaningful plots, an averaging technique was performed on volumetric data only. An outline of this technique is found in Appendix B. It was used on the portions of the plots in Appendix B which contain volumetric data.

Redundant data readings were taken for both load cells and for case pressure. Both load cells contained two independent load measuring devices. While the readings were close, slight differences in calibration resulted in slightly different data points. Two completely independent pressure transducers were mounted on the igniter closure. While data from these transducers agreed closely, a slight difference did exist. Plots of all combinations of redundant data are contained in Appendices B and C.

Data were recorded on a digital system at a rate of eight samples per second. This system is capable of recording data with an uncertainty of less than 1 percent.

## CONCLUSIONS

The TE-M-364-19 motor case demonstrated a safety factor greater than the 1.25 minimum. Assuming the case was at 70°F during testing, internal pressure was 1.32 MEOP, and external axial loading was 1.29 maximum expected instantaneous thrust.

APPENDIX A

HYDROTEST FOR FLTSATCOM SETUP PROCEDURES, TEST PROCEDURES, AND SUPPLEMENTAL INFORMATION

## HYDROTEST FOR FLTSATCOM
## SETUP PROCEDURE

1. Receive the FLTSATCOM motor case and inspect for damage. Report findings to Mr. A. Bassoni or Lt R. Brown.

NOTE 1: Representatives of TRW, Inc., or Thiokol Corporation, are to be present when the motor case is uncrated.

NOTE 2: Take special care not to damage strain gages and strain gage leads.

2. Clean nozzle and igniter opening areas of the case and check igniter closure (AFRPL drawing X7712020) threads for damage.

3. Install Flight Attach Ring (TRW, part LX371), "Z"-ring, on aft side of motor case mounting flange. Insert bolts (TRW-SP7121V4-7TF) and secure using washers (TRW-NAS620A416) and nuts (TRW-MS21043-4). Torque to 132 in.-lb.

NOTE: Leave three (3) bolts out, $120^{\circ}$ apart, for lifting eyes.

4. Coat aft closure "0"-ring (Thiokol drawing E11843) with DC-11 and install on aft closure (AFRPL drawing X7712019A).

5. Place hydraulic ram on base on hydrotest fixture (AFRPL drawing X7712014A). Place hand pump, attached to hydraulic ram, behind barricade.

6. Install load cell #1 (0-60,000 lb) on aft closure.

7. Install hydraulic ram adapter (AFRPL drawing X7712021) on bottom of load cell.

8. Place aft closure, load cell combination on hydraulic ram.

NOTE: This combination must be situated low enough in the test fixture so it will not contact the case when it is lowered into the fixture during step 9.

9. Install motor case in test fixture, remove lifting eyes, and insert the three (3) remaining bolts, (TRW-SP7121V4-7TF), washers (TRW-NAS620A416), and nuts (TRW-MS21043-4) attaching the "Z"-ring to motor case flange. Torque bolt to 132 in.-lb.

10. Align the "Z"-ring bolt holes with the holes in the test fixture. Insert bolts (AFRPL Grade 5) through the "Z"-ring into the test fixture. Use a washer and nut to secure bolt. Torque bolts to 95 in.-lb.

11. Use hydraulic ram to raise aft closure to mate with aft end of case. Align bolt holes and insert washers (Thiokol-AN960516) and bolts (Thiokol SK5051). Torque bolts to 150 in.-lb. Hydraulically lower ram until it is clear of the closure.

12. Install load cell #2 (0-500 lb) on tripod.

13. Have instrumentation connect to data acquisition systems:

a. Load cell #1, 0-60,000 lb

b. Load cell #2, 0-500 lb

c. Pressure transducers (strain gage type), 2 each, 0-1500 psi

d. Thermocouple (Cr-Al) water temperature

e. Strain gages (supplied and installed by Thiokol Corporation), 20 each

14. Use 1/2 inch stainless steel tubing to connect outlet of hydrostatic pump to nozzle adapter plate.

15. Place water tank upright on ground near load cell #2. Use 3/4 inch plastic tubing to connect outlet of water tank to inlet of hydrostatic pump.

HYDROTEST FOR FLTSATCOM
TEST PROCEDURE

1. Comply with all parts of Setup Procedures.

2. Place spacer under water tank so there is no load on load cell #2.

3. Instrumentation perform "Z" cal.

4. Hydraulically raise the thrust ram until it contacts the hydraulic ram adapter.

5. Remove spacer so that water tank hangs from load cell #2.

6. Instrumentation record offset on load cell #1 (0-60,000 lb) and load cell #2 (0-500 lb).

7. Fill the case with water through the igniter port.

8. Load the water container with fifteen (15) gallons of water.

9. Coat the igniter "O"-ring (Thiokol drawing E-11878) with DC-11 and install it on the igniter closure.

10. Install the igniter closure on the motor.

11. Tighten the igniter closure with a special spanner wrench (fabricated at RPL). Torque to 400 in.-lb.

12. Connect pressure transducers and transducer tubing to the igniter closure.

13. Take pre-test photo (still).

14. Use the hydrostatic pump (Haskel A0-35) to complete filling the case with water, allowing any trapped air to escape through the igniter closure overflow valves.

NOTE: Should pressure gage #2 read more than 500 psi greater than pressure gage #1 or should pressure gage #2 read more than 2500 psi,the test will be discontinued. See Figure A-1. Remove the axial loading and depressurize the case. When obstruction has been cleaned from pressure line, begin test procedure again from step 1.

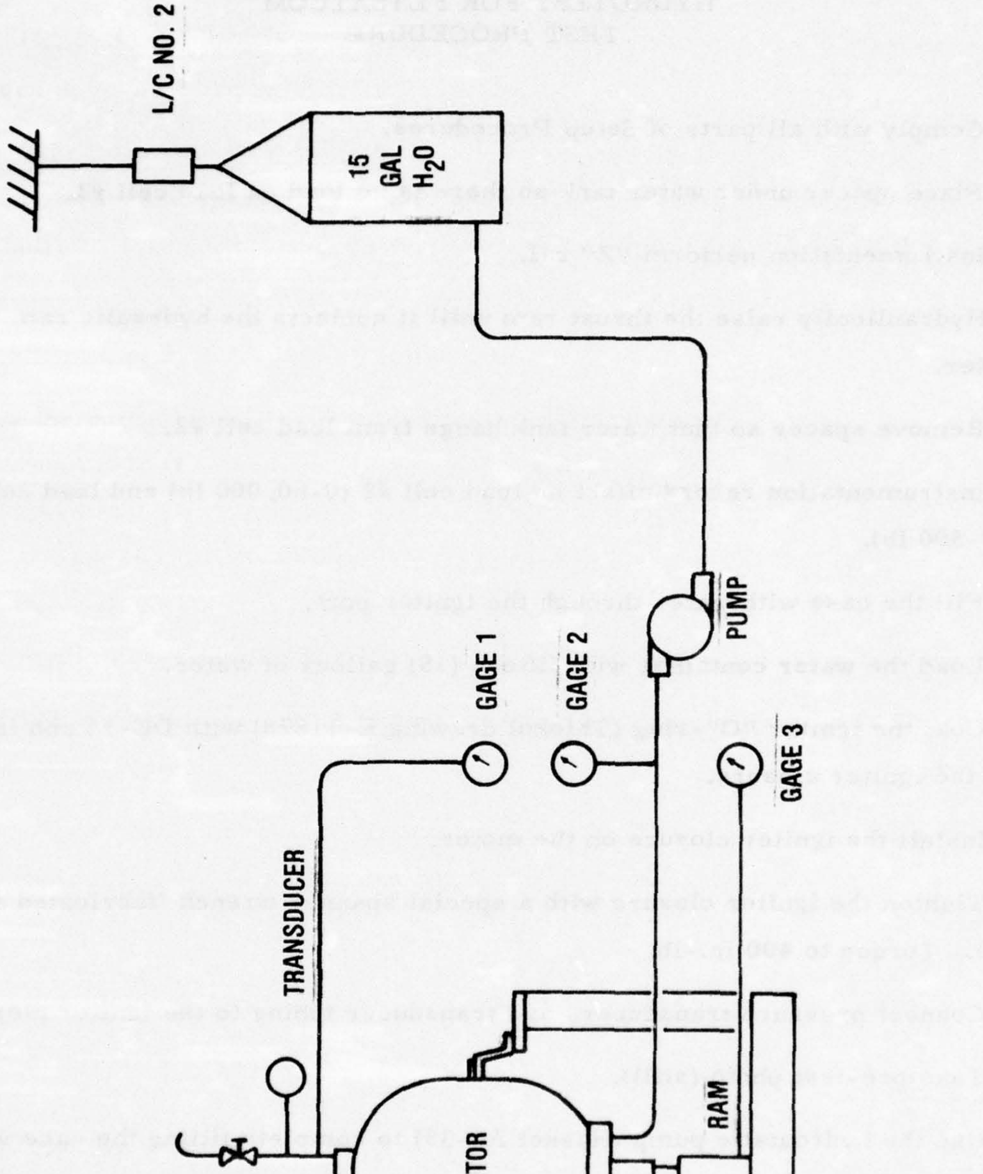


Figure A-1. Hydrotest Equipment Arrangement.

15. When all air has been purged from the case, close the igniter closure overflow valves and then turn off the hydrostatic pump.

16. Slightly open one of the igniter closure overflow valves, allowing the case pressure to stabilize at ambient pressure. Close the overflow valve.

17. Start continuous instrumentation (digital, oscillograph, and strip chart). Obtain instrumentation offset on load cell #1 (0-60,000 lb) and load cell #2 (0-500 lb).

18. Begin application of axial force and case pressurization according to the curve in Figure A-2. Continue until reaching point A (4040 $lb_f$ beyond instrumentation offset and 200 psig).

NOTE 1: Pressure gage #3 will be used to determine axial force. Pressure gage #1 will be used to determine case pressure. See Figure A-1.

NOTE 2: Should pressure gage #2 read more than 500 psi greater than pressure gage #1 or should pressure gage #2 read more than 2500 psi, the test will be discontinued. See Figure A-1. Remove the axial loading and depressurize the case. When obstruction has been cleaned from pressure line, begin test procedure again from step 1.

19. Hold axial force and case pressure at point A of Figure A-2 for two (2) minutes. Remotely inspect system for leaks and verify that the transducers, load cells, and strain gages are operating properly.

NOTE: If no leaks or instrumentation/mechanical problems are detected continue the test with step 20. If there is a leak (indicated by a 20 psi loss of case pressure) and/or an instrumentation/mechanical problem, the test will be discontinued. Remove the axial loading and depressurize the case. When the problem(s) is (are) corrected, begin the test procedure again from step 1.

20. Resume the application of axial force and case pressurization[1] along the curve in Figure A-2.

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[1] The rate of case pressurization will be greater than 100 psi/min.

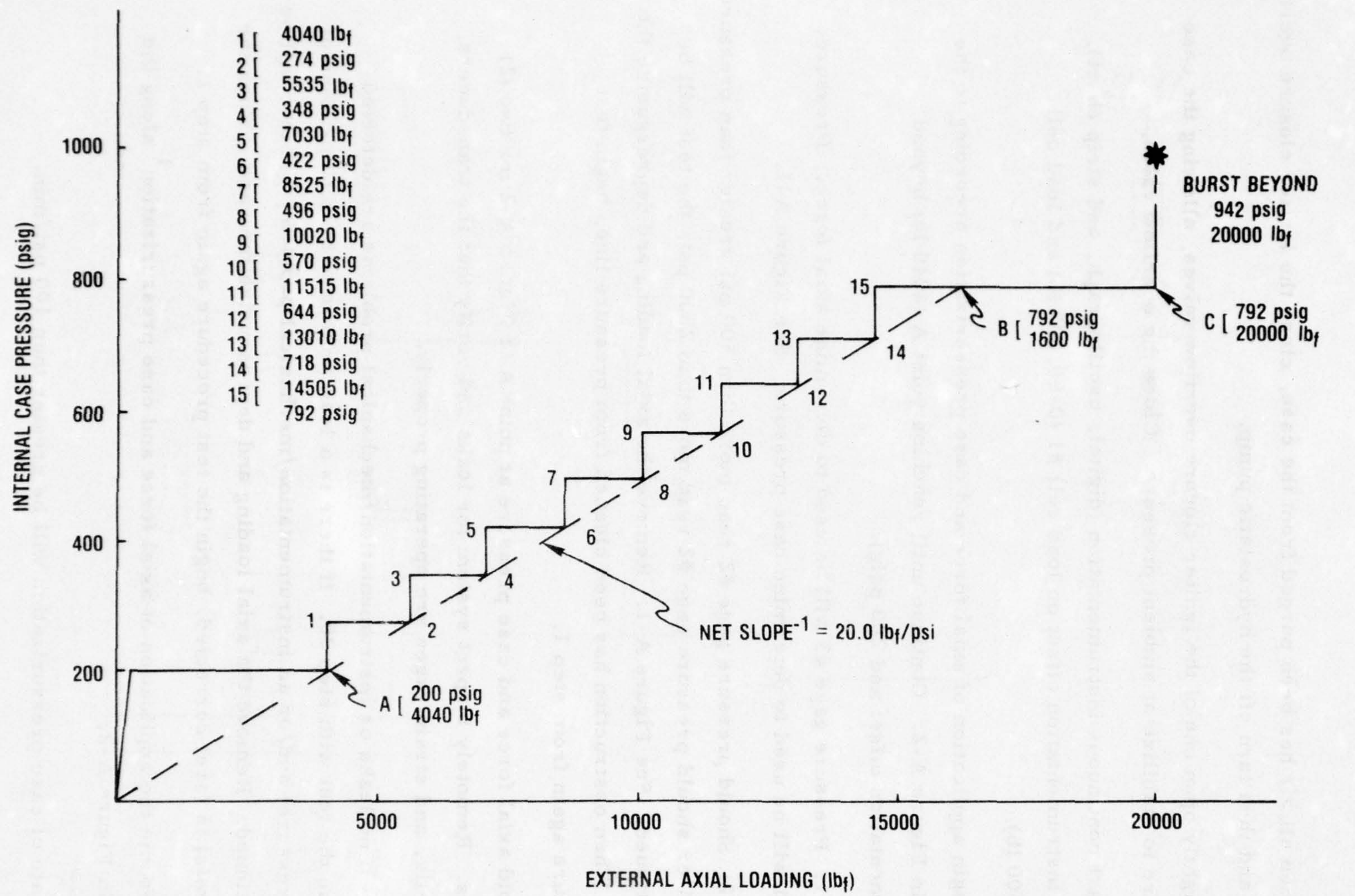


Figure A-2. Loading Curve for TE-M-364-19 AKM Case.

NOTE 1: Should pressure gage #2 read more than 500 psi greater than pressure gage #1 or should pressure gage #2 read more than 2500 psi the test will be discontinued. See Figure A-1. Unloading will be reverse of loading curve in Figure A-2. When obstruction has been cleaned from pressure line begin procedure again from step 1.

NOTE 2: Should the case break prematurely, immediately stop hydrostatic pump and go to step 29.

21. As axial force and case pressure reach point 12 (13, 010 $lb_f$ beyond instrumentation offset and 644 psig) in Figure A-2, start documentation cameras (Milligans @ 24 fps).

22. Continue with application of axial force and case pressurization[1] until reaching point 13 (16, 000 $lb_f$ beyond instrumentation offset and 792 psig $^{+10}_{-0}$ psig) in Figure A-2.

23. Hold axial force and case pressure at point B for one (1) minute. Check instrumentation for indication of problems.

NOTE: If no problems were detected during the hold, continue the test with step 24. If a problem developed where the case failed to maintain pressure (20 psi loss) during the hold, the test will be discontinued. Unloading will be reverse of loading curve in Figure A-2. When the problem(s) is (are) corrected, begin the test procedure again from step 1.

24. Increase axial force while holding case pressure constant until reaching point C in Figure A-2 (20, 000 $lb_f$ beyond instrumentation offset and 792 psig).

25. Hold axial force constant at 20, 000 $lb_f$ beyond instrumentation offset and increase case pressurization.[2]

---

[1] The rate of case pressurization will be greater than 100 psi/min.

[2] The rate of case pressurization will be the maximum the Haskel A0-35 pump can deliver. (The pump is rated to deliver water at a rate of 345 $in.^3$/min when case pressure is 1000 psig.)

NOTE: Should pressure gage #2 read more than 500 psi greater than pressure gage #1 or should pressure gage #2 read more than 2500 psi, the test will be discontinued. See Figure A-1. Unloading will be reverse of loading curve in Figure 2. When obstruction has been cleaned from pressure line, begin procedure again from step 1.

26. As case pressure reaches 850 psig, start high speed camera (Hycams @ 400 fps).

27. Continue case pressurization[2] until burst[3].

NOTE: Should pressure gage #2 read more than 500 psi greater than pressure gage #1 or should pressure gage #2 read more than 2500 psi the test will be discontinued. See Figure A-1. Unloading will be reverse of loading curve in Figure A-2. When obstruction has been cleaned from pressure line, begin procedure again from step 1.

28. When the case burst, immediately stop the hydrostatic pump.

29. Stop continuous instrumentation.

30. Stop all motion picture cameras.

31. Take post-test photo (still) and unload motion picture cameras.

NOTE: The failed case will be released to Thiokol (Elkton Division) for transportation to their facility. Thiokol will perform a post-test analysis on the case.

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[2] The rate of case pressurization will be the maximum the Haskel A0-35 pump can deliver. (The pump is rated to deliver water at a rate of 345 $in.^3$/min when case pressure is 1000 psig.)

[3] Burst is expected to occur at an internal case pressure of about 1050 psig when ambient temperature is $70^oF$ and ambient pressure is that of sea level.

SUPPLEMENTAL INFORMATION FOR FLTSATCOM HYDROTEST PROCEDURE
PROJECT 920BOONC

## OBJECTIVE

The FLTSATCOM Ultimate Pressure/Load test as planned by the Air Force has the specific objective of establishing failure pressure for a typical fired production case, comparing the failure value obtained directly to the specification requirement to ascertain compliance. To permit a more rigorous evaluation of the structural capability of the case, and to compare the test results to the design analysis, it is necessary to acquire data relative to stress state and volumetric change as a function of pressure in critical locations on the pressure vessel. To achieve this result the test article has been instrumented with nine biaxial strain gages. The strain gages, electrical circuitry, method of application, data requirements, and hardware disposition are described in subsequent sections.

## STRAIN GAGES

These are self temperature compensating gages - Micro-Measurements type EA05-062TT-120 - matched for use on titanium. The two elements of the gage are oriented $90^{\circ}$ to each other and are electrically independent. Each element has a nominal resistance of 120 ohms and a gage factor of 2.04. The gage length is .062 inches.

## CIRCUITRY

Each strain gage element forms the active arm of a conventional 4-arm Wheatstone bridge circuit, the other three arms are comprised of fixed precision resistors (120 ohm, .02 percent) mounted on phenolic terminal boards located in close proximity to the active strain gage. Figure A-3 attached shows the circuit schematic representative of each channel, including the color code. Fifteen (15) feet of 4 conductor shielded cable is provided to interface with RPL's instrumentation system. The cable shield is <u>not</u> connected at the gage. The phenolic terminal board layout typical of a strain gage location is also shown.

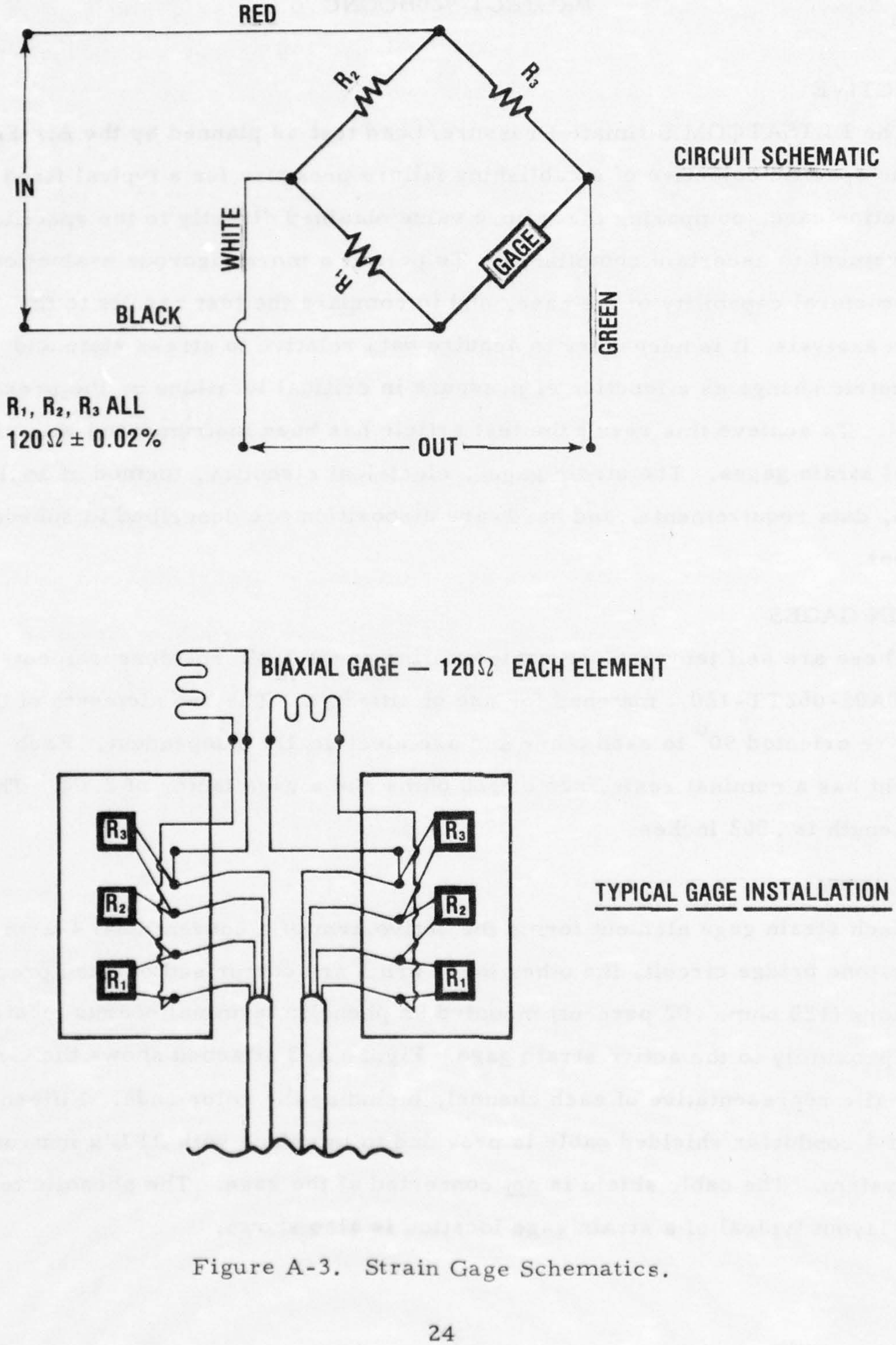


Figure A-3. Strain Gage Schematics.

ADHESIVES AND COATINGS

The strain gages are bonded to the case in the locations shown on Figure A-4 with Micro-Measurements M-Bond 200 adhesive (selected Lot Eastman 910) from Lot No. 489. Shelf life expiration is August, 1977.

The phenolic terminal boards are attached to the case with pads of "Miracle-Seal" sealant (essentially uncured butyl rubber) which produce a strain-free, resilient but very tenacious bond.

The strain gage elements are covered with two (2) coats of Gagekote #1 (W. T. Bean, Inc.), a solvent-thinned synthetic resin compound which produces negligible reinforcement. The entire installation is covered with Gagekote #5, a two-component flexible epoxy resin, for mechanical as well as moisture protection.

CALIBRATION

Eighteen (18) calibration resistors are provided. These resistors are comprised of two 5880 ohm resistors connected in parallel to form a 2940 ohm resistor. When placed in shunt across the Black and Green leadwires (active gage), this will produce a signal output equivalent to a strain level of -20,000 microinches per inch (compression). Alternately, if placed across the Black and White leadwires (RI resistor), the equivalent strain output will be +20,000 microinches per inch (tension).

All strain gages were checked for balance and response to a small compressive strain applied at each gage location.

DATA REQUIRED

a. Plot data of strain (axial and hoop) versus pressure. One biaxial gage per plot (9 plots required). Strain to be in micro in./in.

b. Plot of pressure versus time

c. Plot of change-in-volume versus pressure

d. Plot of change-in-volume versus time

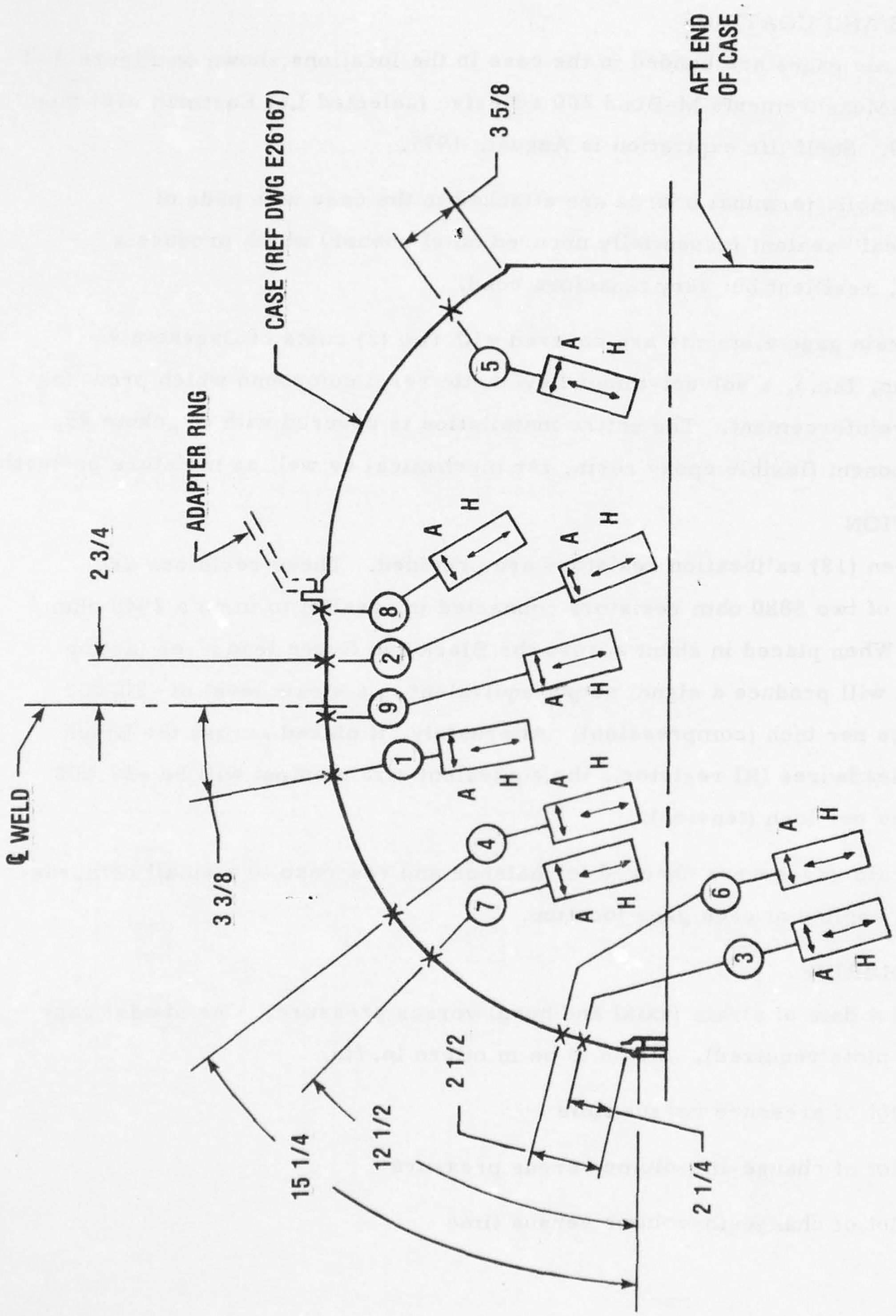


Figure A-4. Strain Gage Locations.

## STRAIN GAGE RESPONSE VERIFICATION

During the hold described in the procedure for the verification of system leak integrity, (Reference Step 19 of Hydrotest Procedure) verify strain gage response. The approximate values for each strain gage under an imposed pressure load of 200 psi are as follows.

| Gage No. | Strain ($\mu$ in. /in.) | Gage No. | Strain ($\mu$ in. /in.) |
|---|---|---|---|
| 1A | 1300 | 6A | 1700 |
| 1H | 1200 | 6H | 1600 |
| 2A | 500 | 7A | 1500 |
| 2H | 1800 | 7H | 1450 |
| 3A | 1700 | 8A | 300 |
| 3H | 1600 | 8H | 1200 |
| 4A | 1500 | 9A | 1000 |
| 4H | 1450 | 9H | 1600 |
| 5A | 1300 | | |
| 5H | 1300 | | |

A Axial Direction
H Hoop Direction

## HARDWARE DISPOSITION

Return fractured case and instrumentation to Thiokol/Elkton for the following reasons:

1. Establish fracture origin
2. Determine thickness in fracture zone
3. To normalize data to minimum design conditions

# APPENDIX B

# PLOTS INVOLVING VOLUME, CASE PRESSURE, TIME, AND AXIAL FORCE

FOR VOLUME PLOTS ONLY:

Data smoothing was accomplished by averaging over N equally spaced data points, where N is an odd integer (1, 3, 5 . . . ), and replacing the $\frac{N-1}{2}$'th data point with a calculated average. For N = 3 then,

$$Y_i = \frac{Y_i-1 + Y_i + Y_i+1}{3}$$

It should be noted that for any N, $\frac{N-1}{2}$ data points will be lost at each end of the data, since no average values can be calculated for those points.

An N of 101 was selected to smooth the volume plots. Without smoothing, 7809 points would have been plotted.

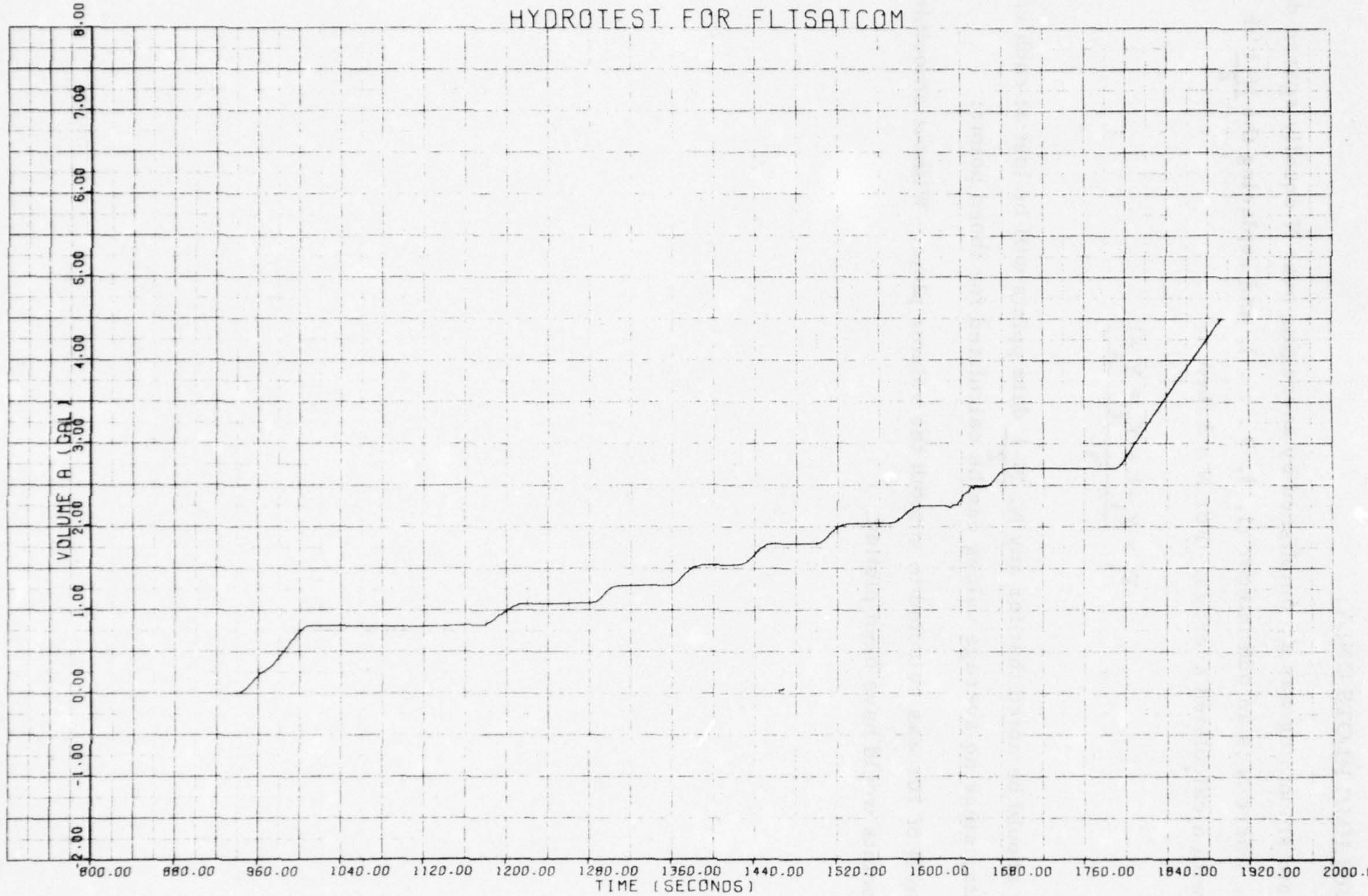


Figure B-1. Volumetric Expansion Profile, Gage 1

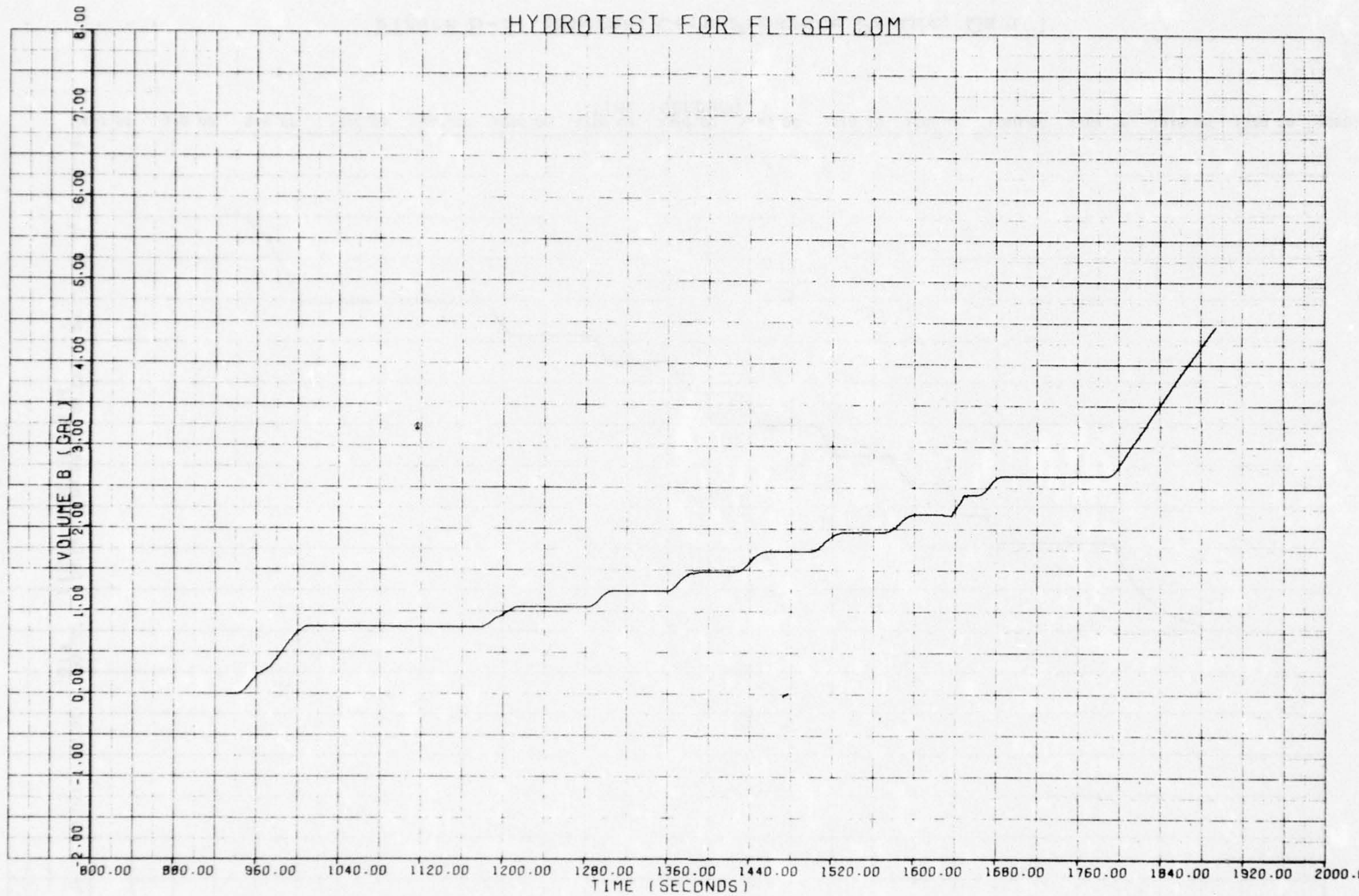


Figure B-2. Volumetric Expansion Profile, Gage 2

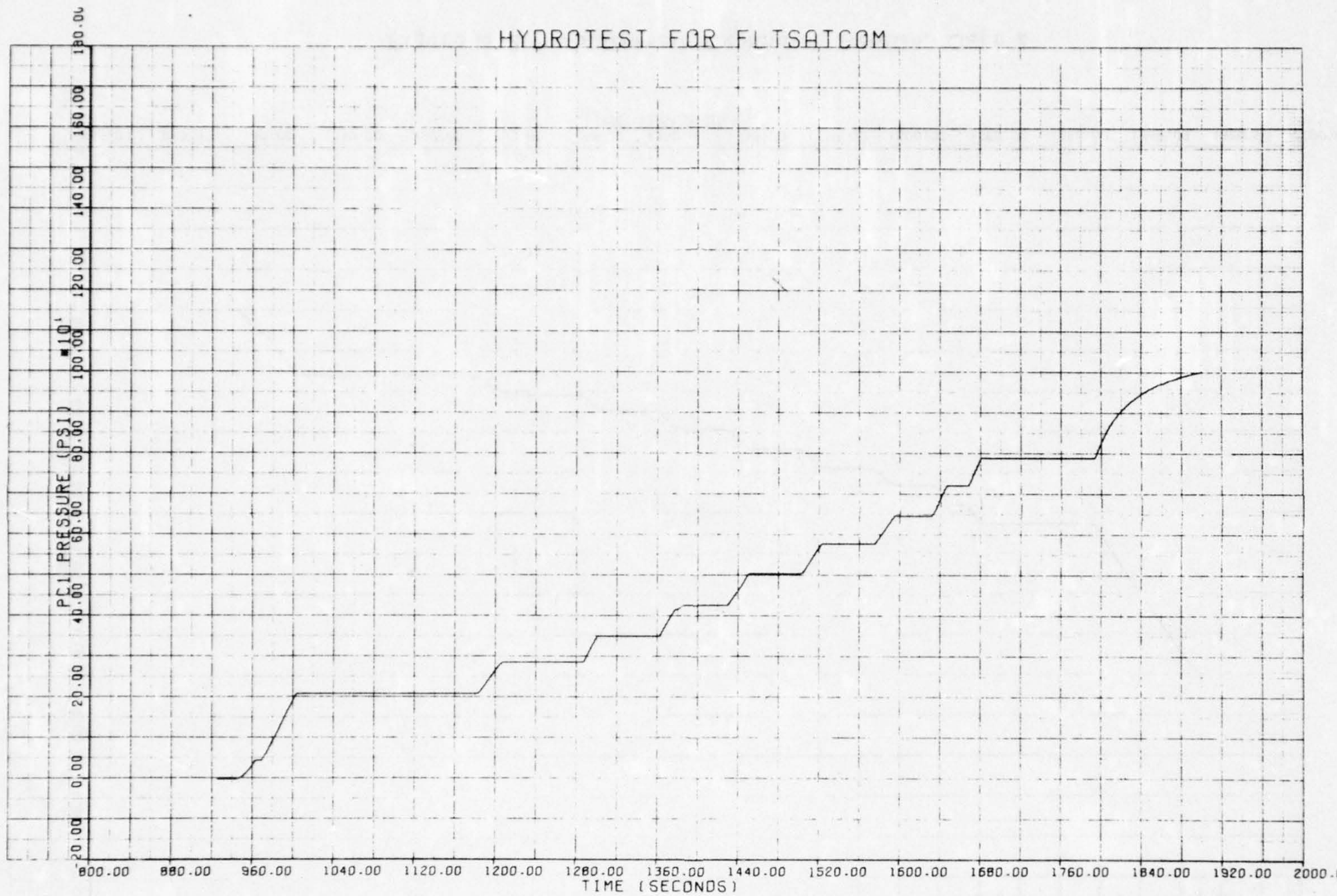


Figure B-3. Internal Case Pressure Profile, Gage 1

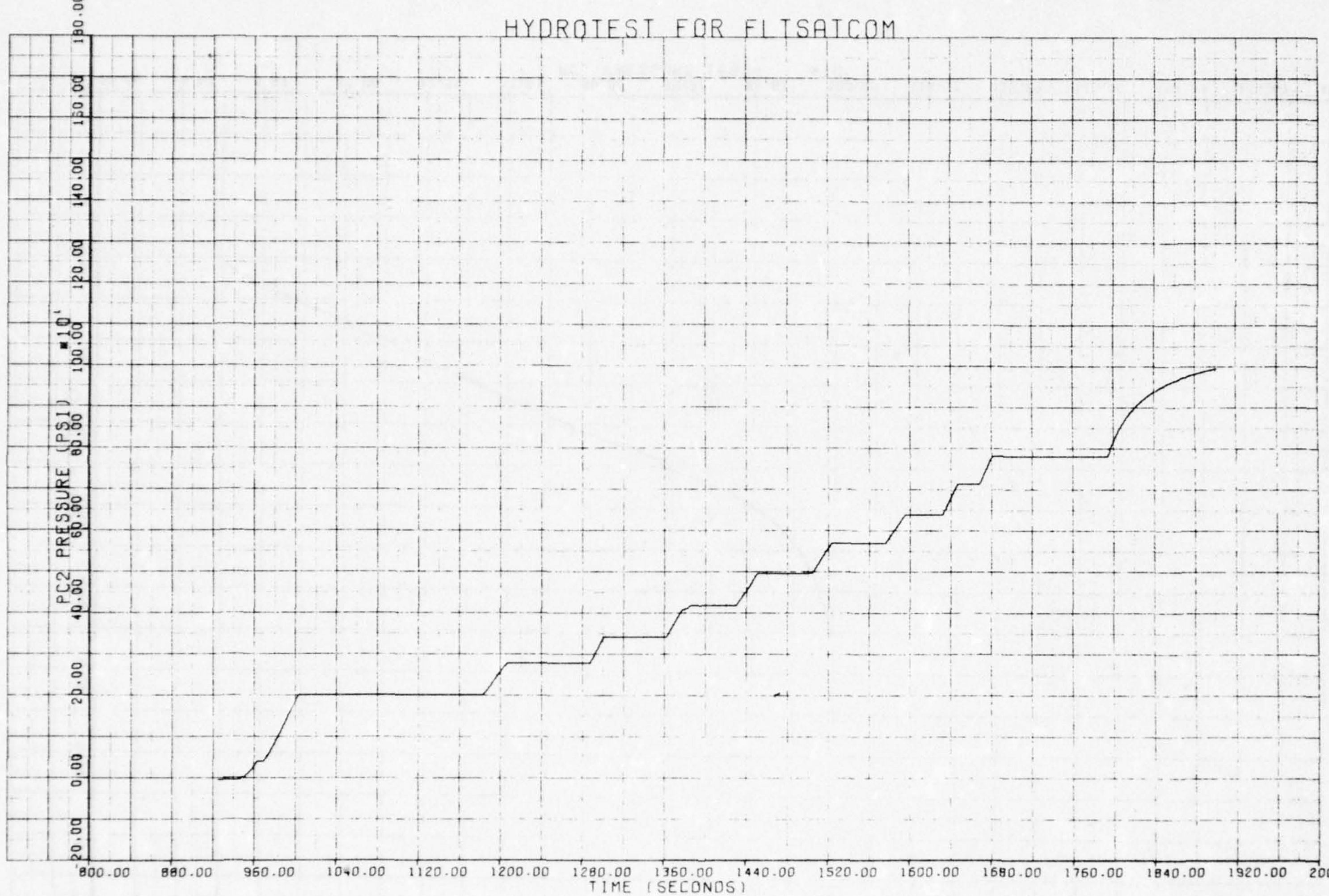


Figure B-4. Internal Case Pressure Profile, Gage 2

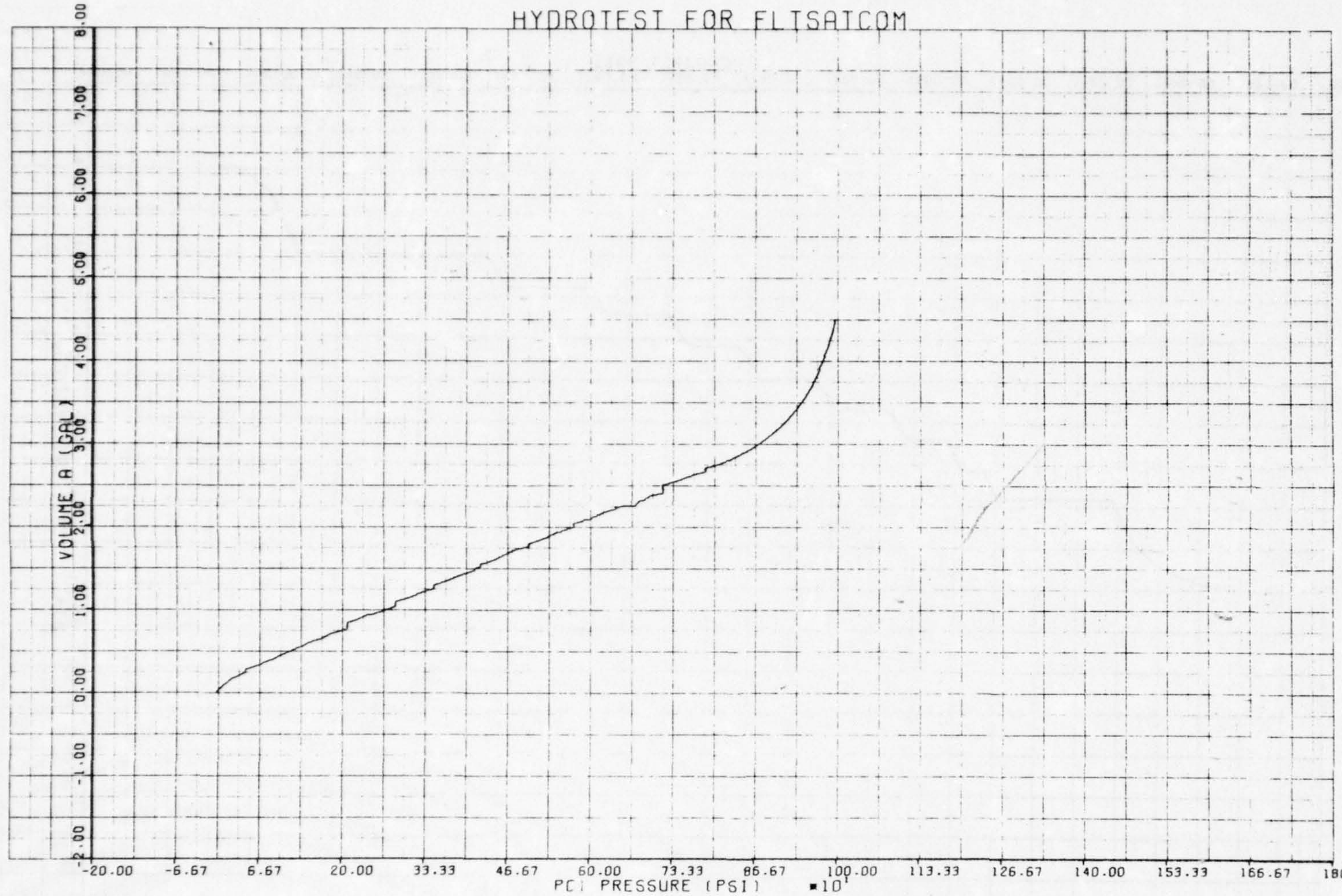


Figure B-5. Volumetric Expansion, Gage 1 vs. Internal Case Pressure, Gage 1

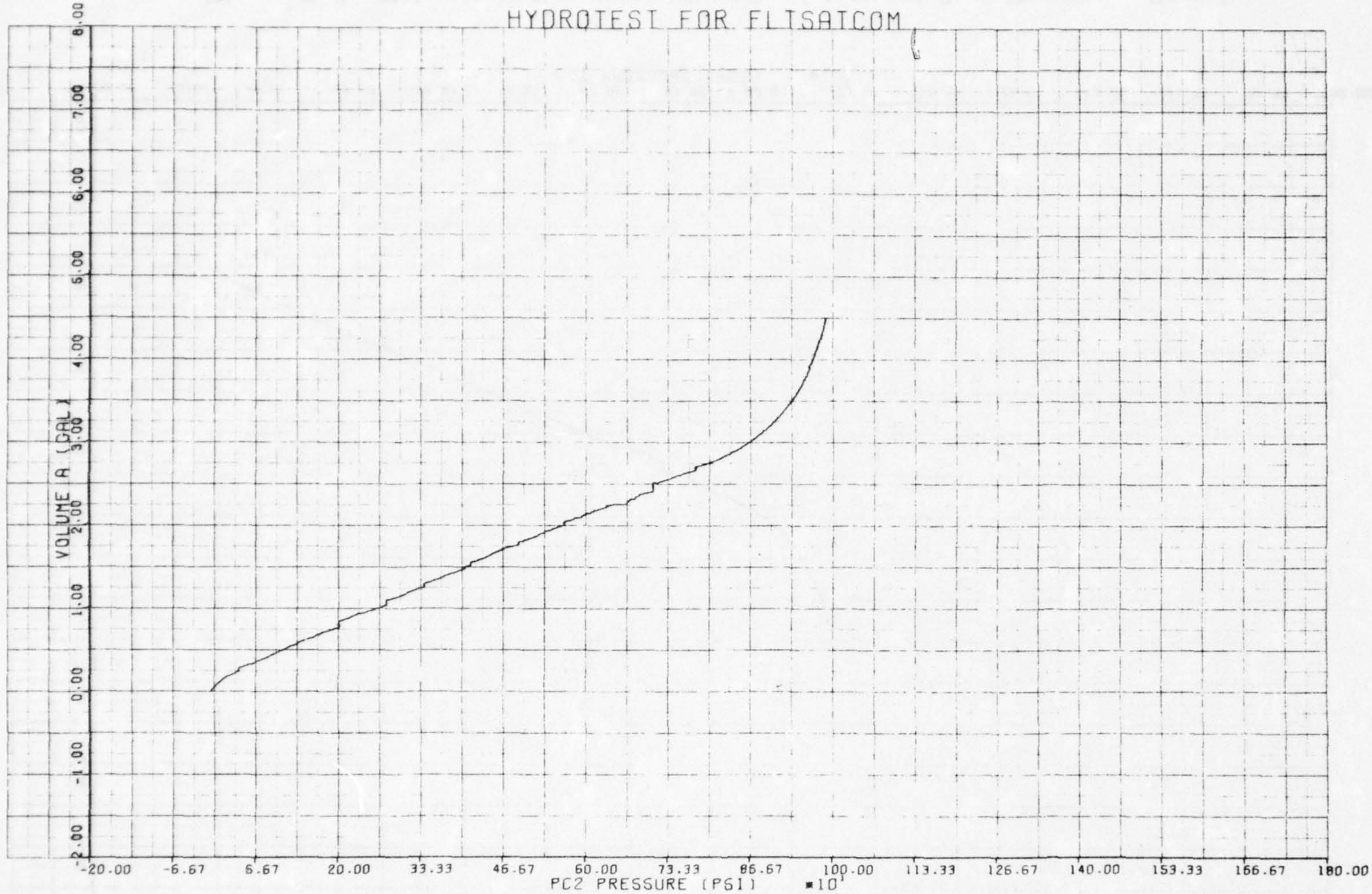


Figure B-6. Volumetric Expansion, Gage 1 vs. Internal Case Pressure, Gage 2

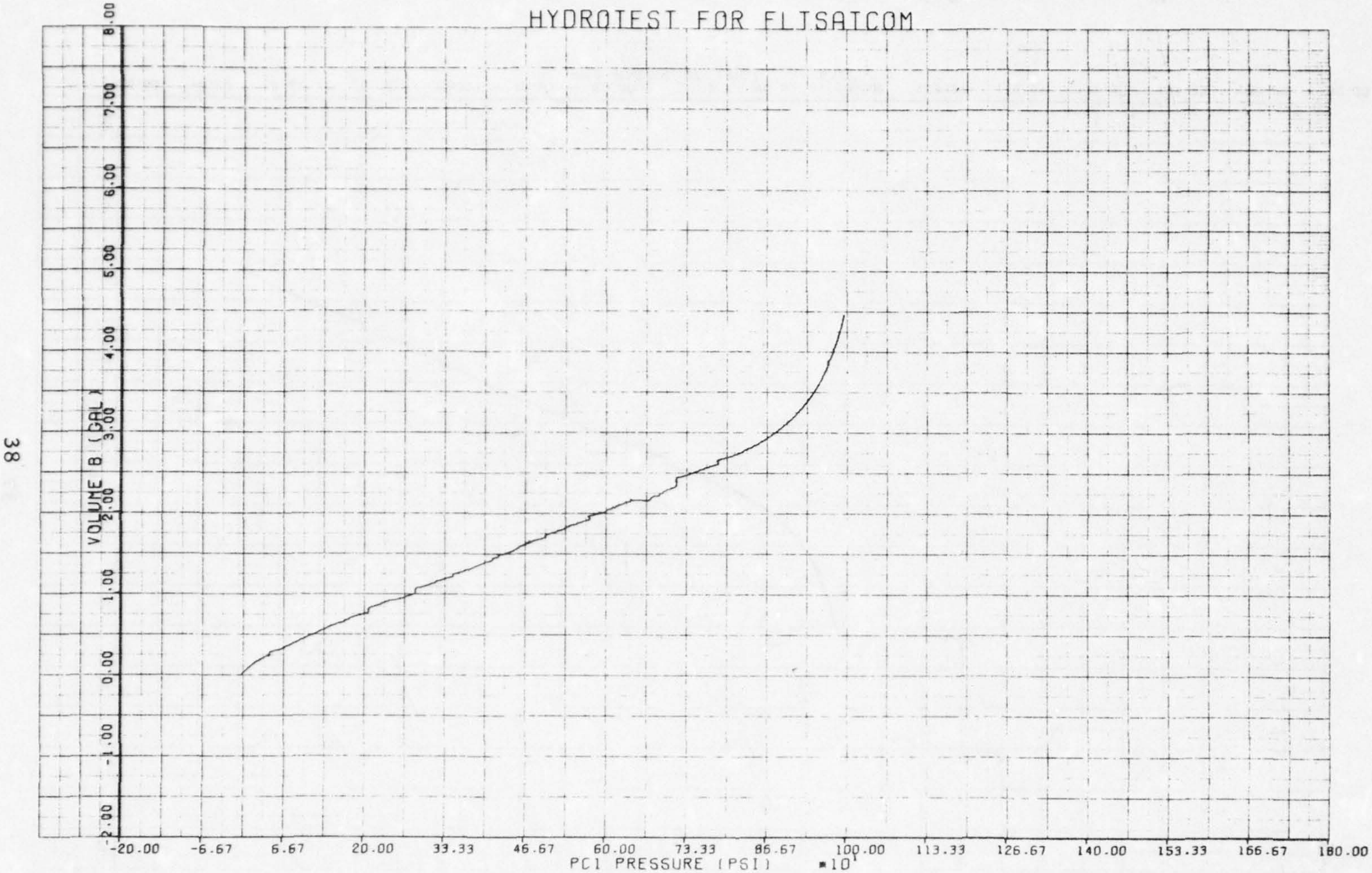


Figure B-7. Volumetric Expansion, Gage 2 vs. Internal Case Pressure, Gage 1

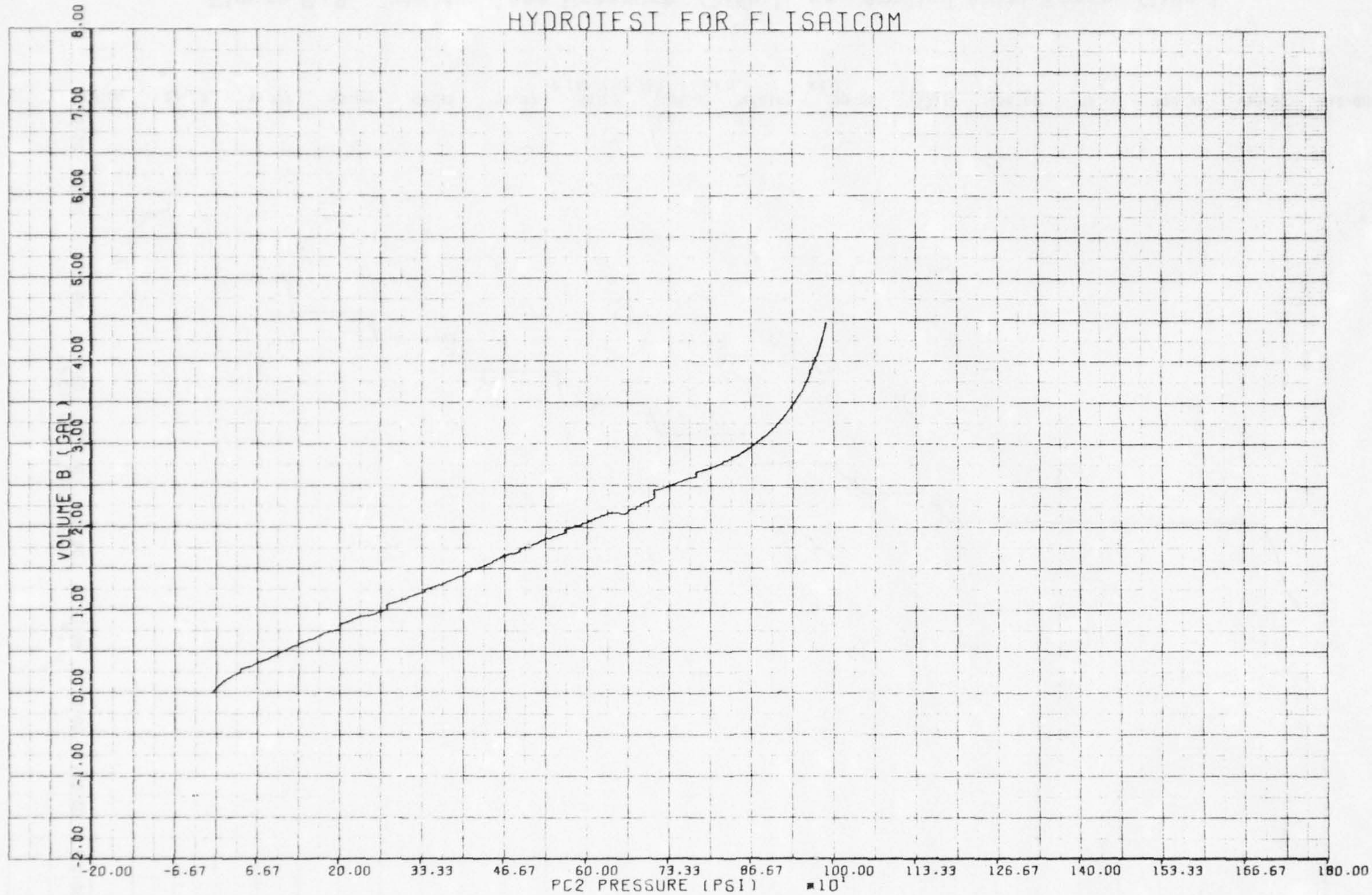


Figure B-8. Volumetric Expansion, Gage 2, vs. Internal Case Pressure, Gage 2

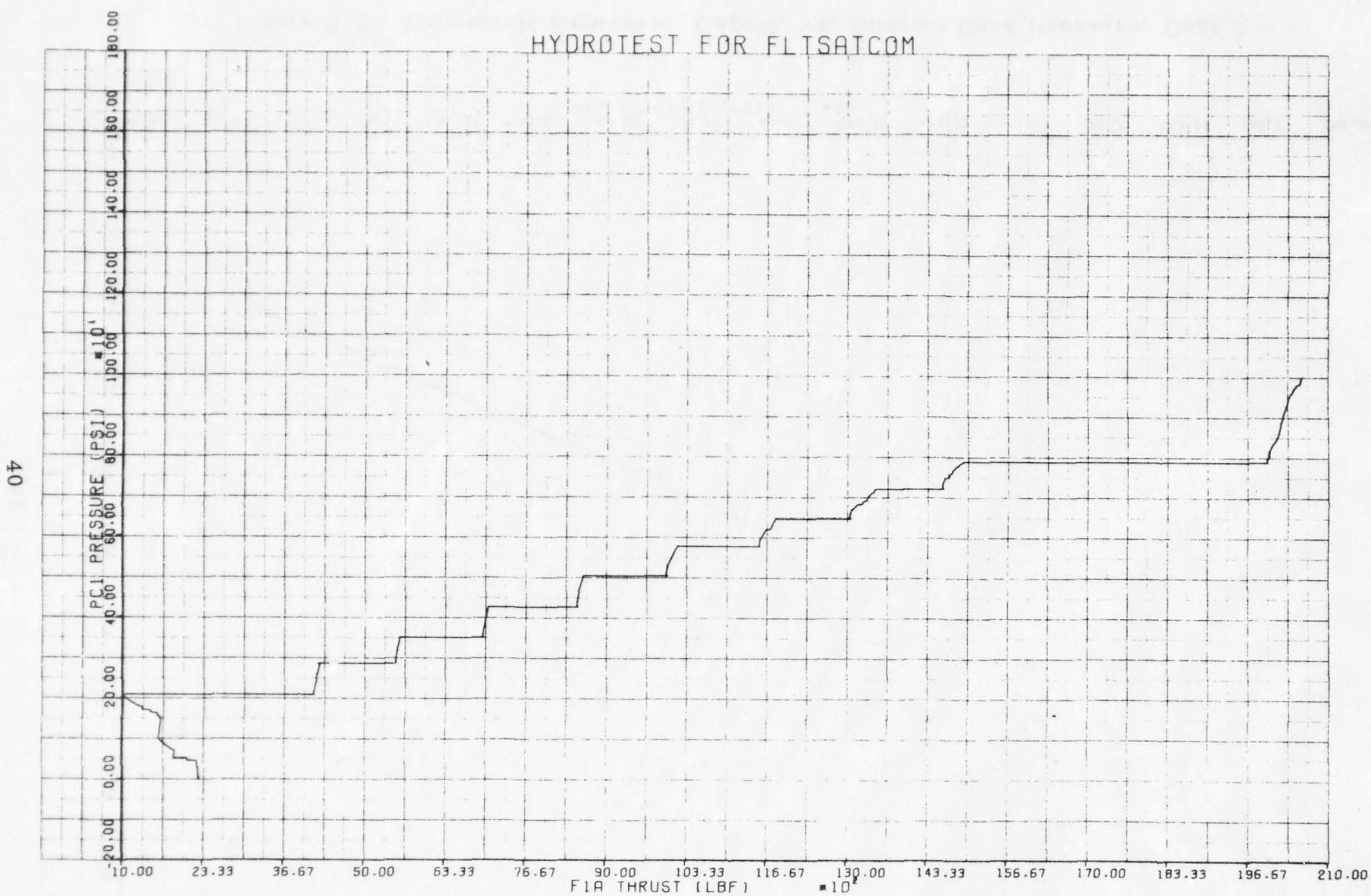


Figure B-9. Internal Case Pressure, Gage 1, vs. Applied Axial Force, Gage 1

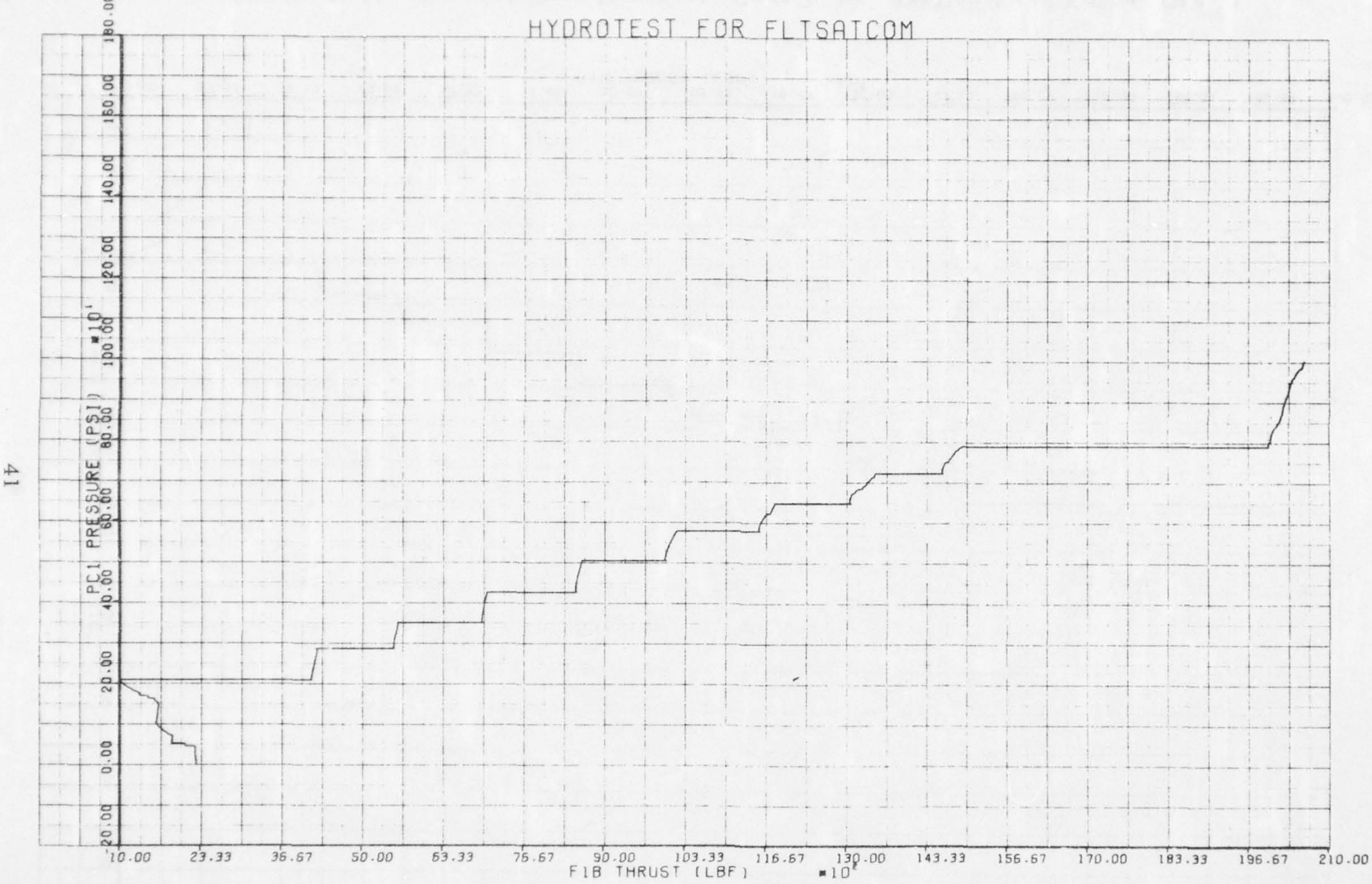


Figure B-10. Internal Case Pressure, Gage 1, vs. Applied Axial Force, Gage 2

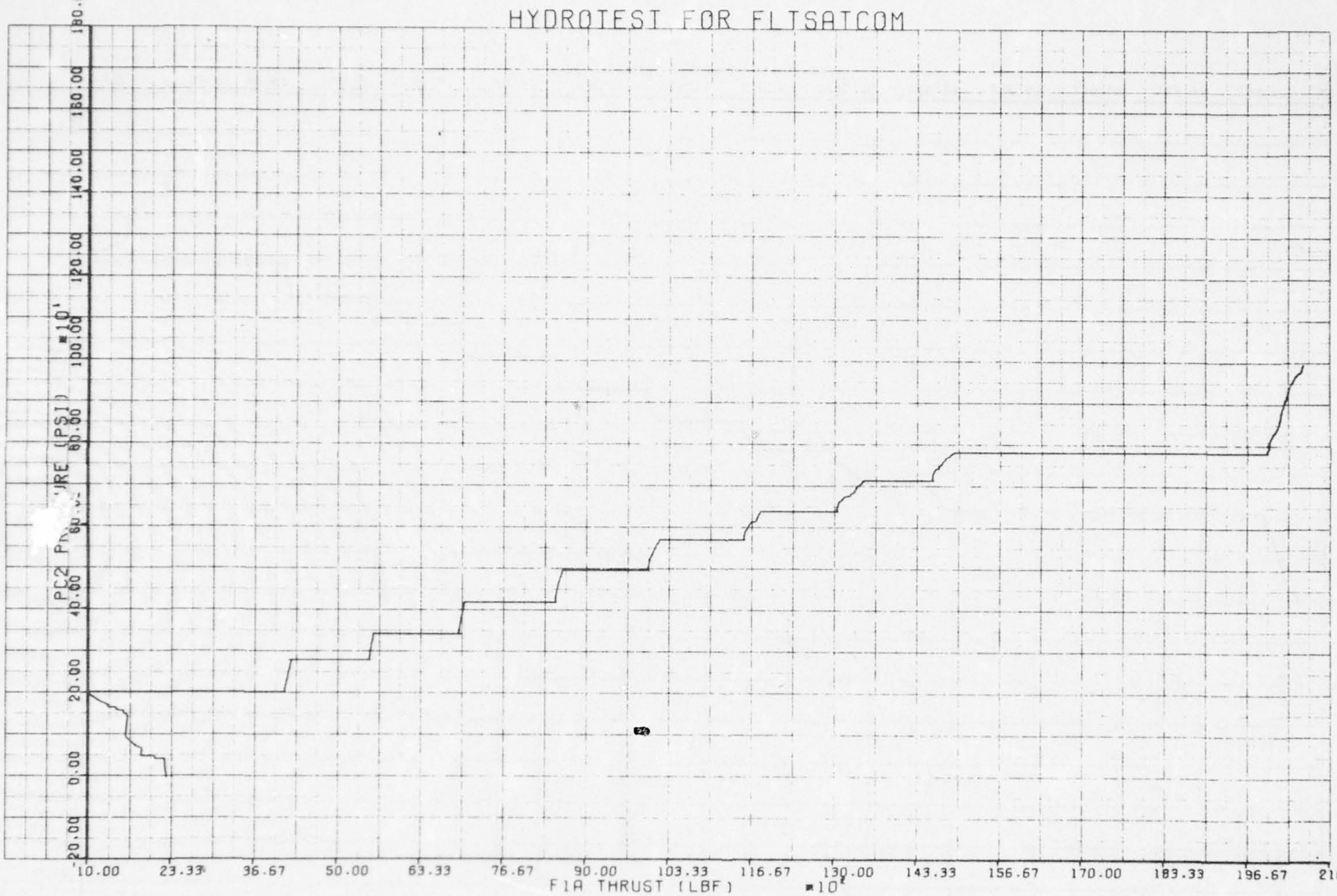


Figure B-11. Internal Case Pressure, Gage 2, vs. Applied Axial Force, Gage 1

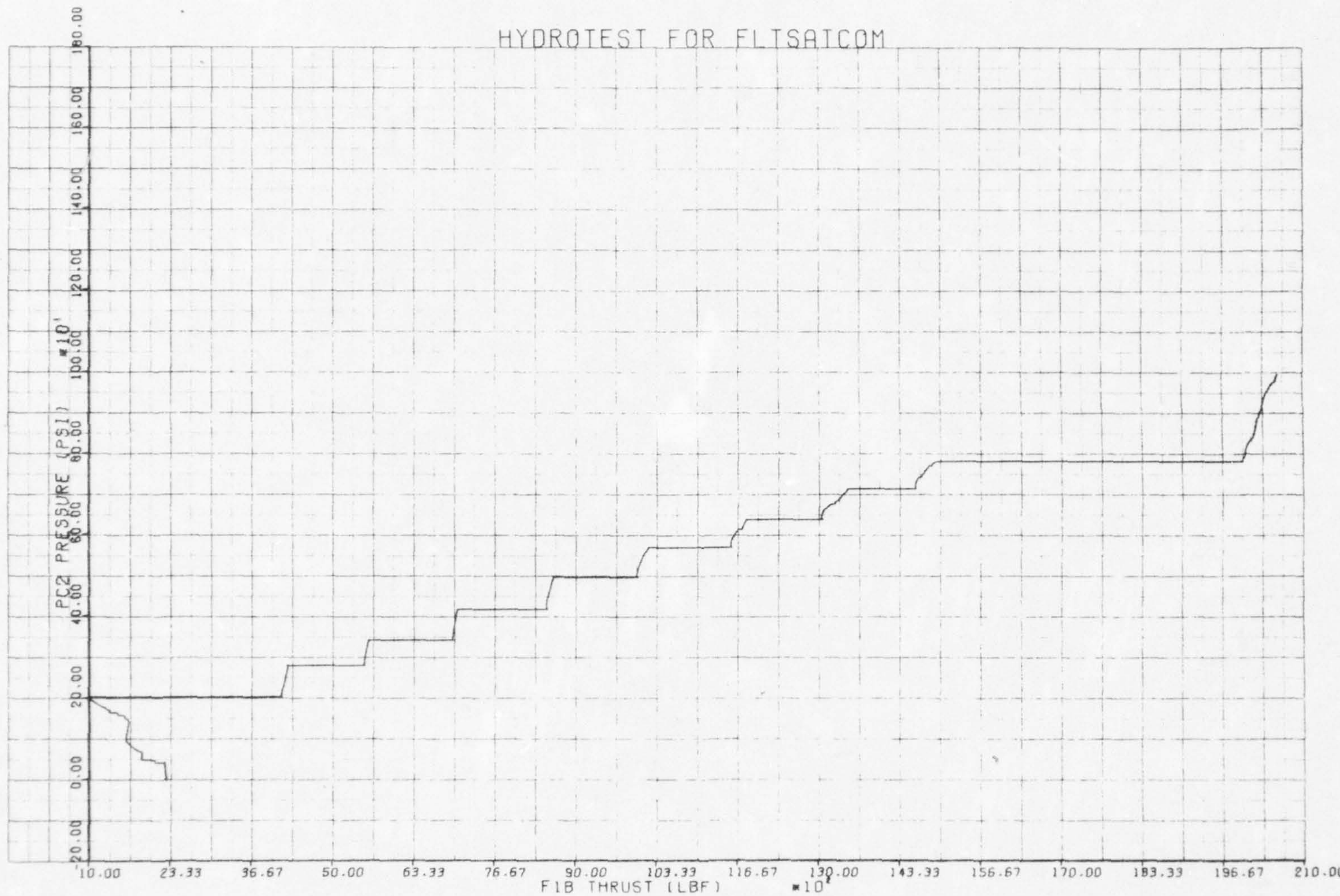


Figure B-12. Internal Case Pressure, Gage 2, vs. Applied Axial Force, Gage 2

APPENDIX C

PLOTS OF STRAIN GAGE DATA

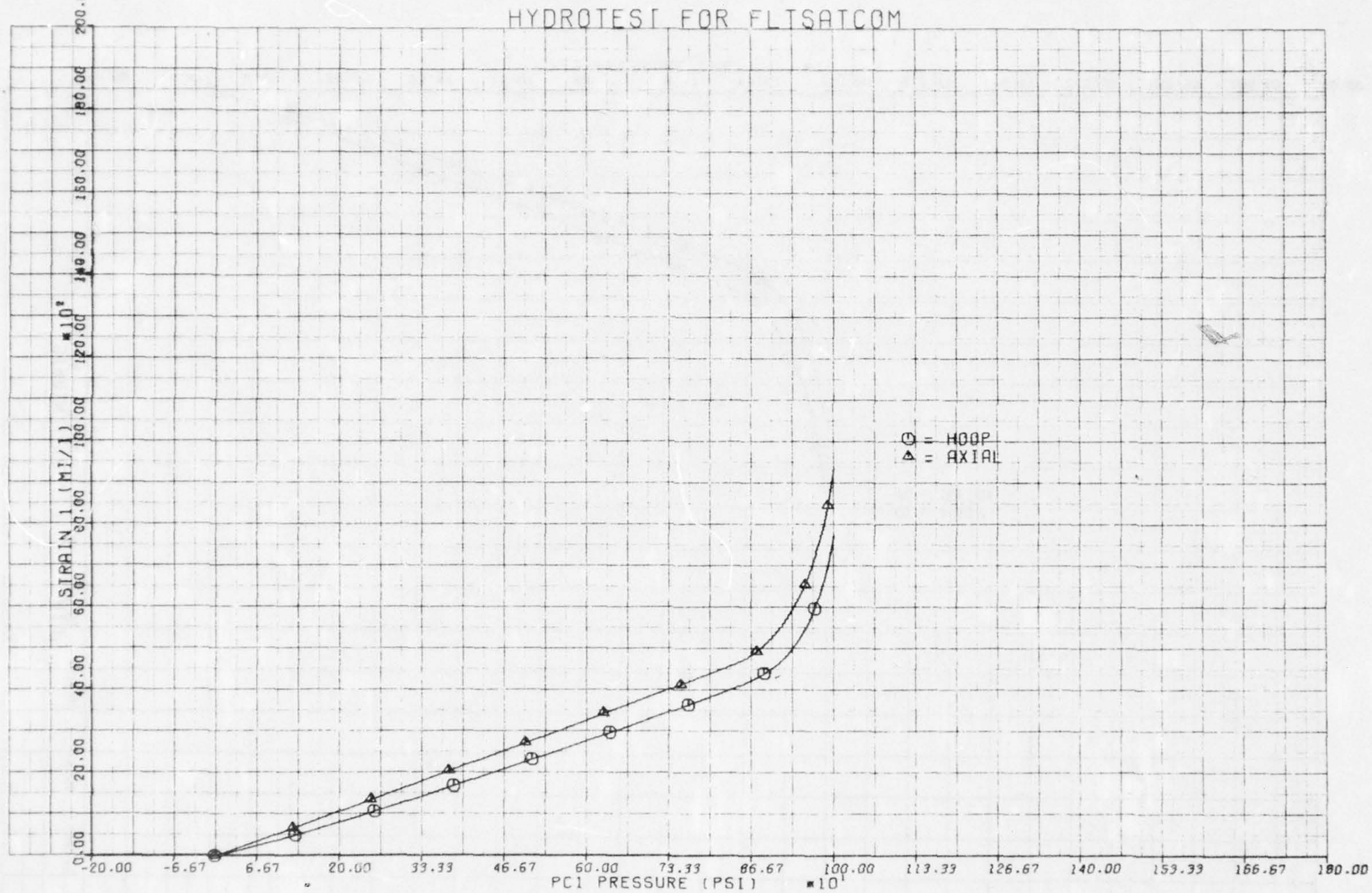


Figure C-1. Strain Gage #1 vs. Internal Case Pressure, Gage 1

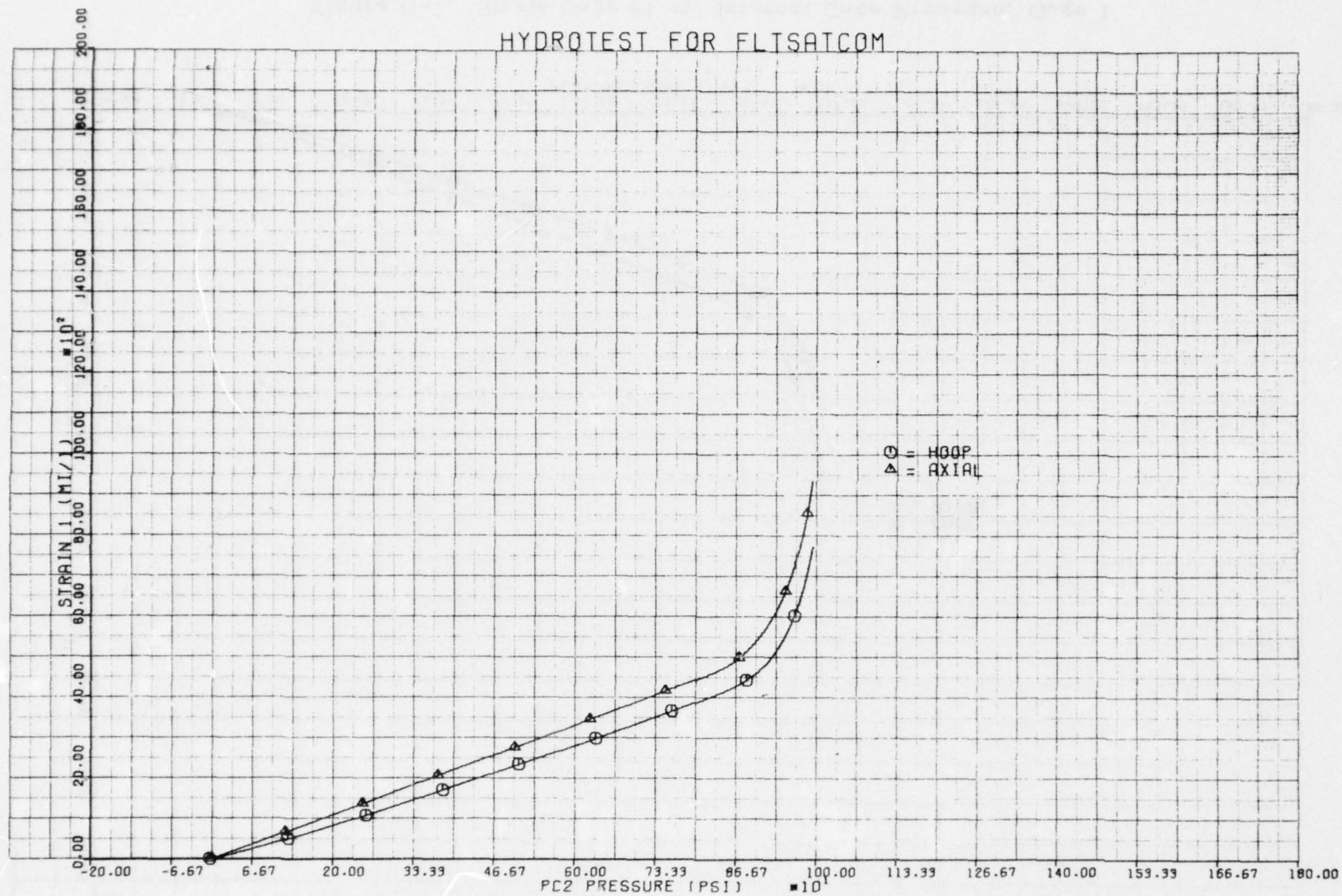


Figure C-2. Strain Gage #1 vs. Internal Case Pressure, Gage 2

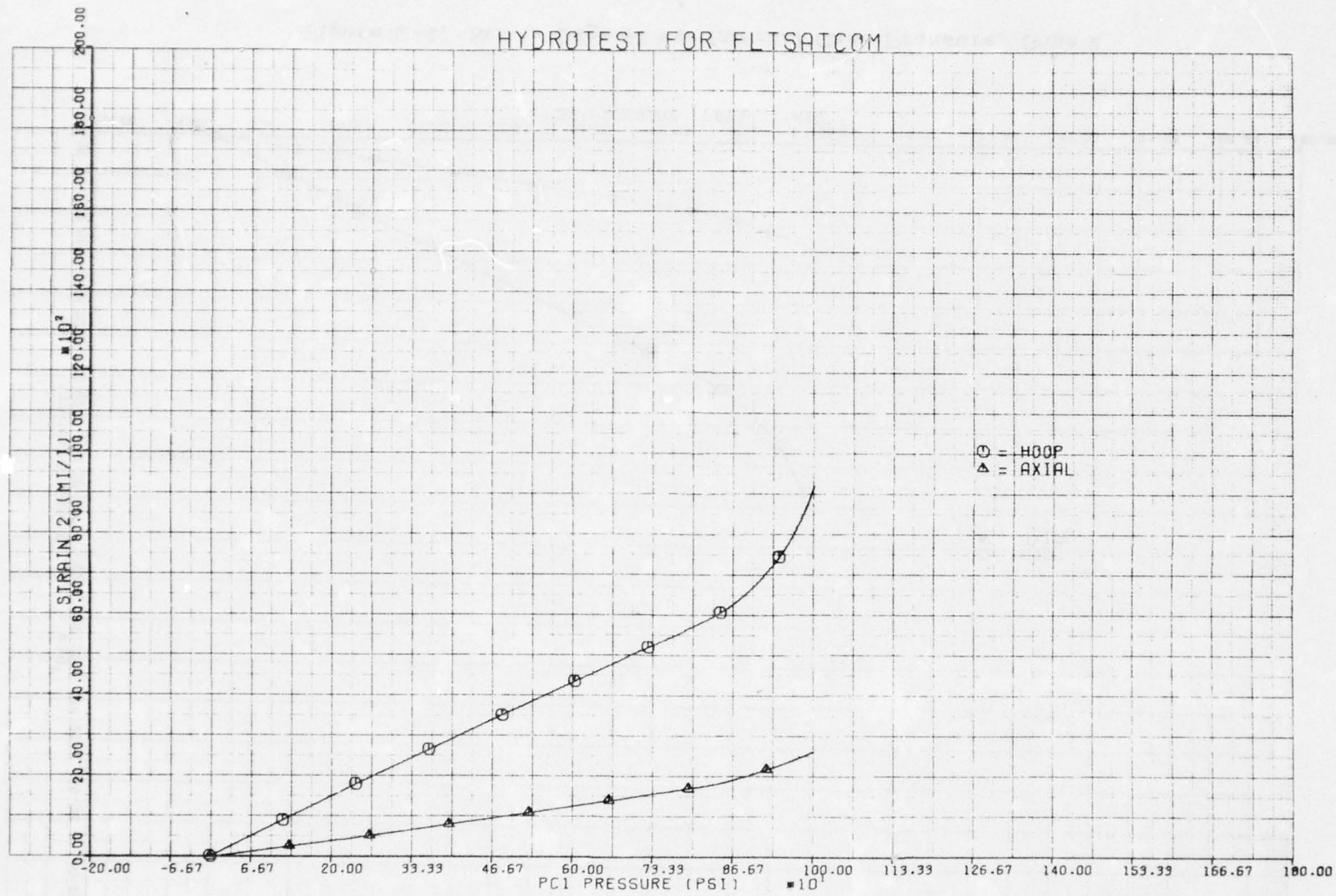


Figure C-3. Strain Gage #2 vs. Internal Case Pressure, Gage 1

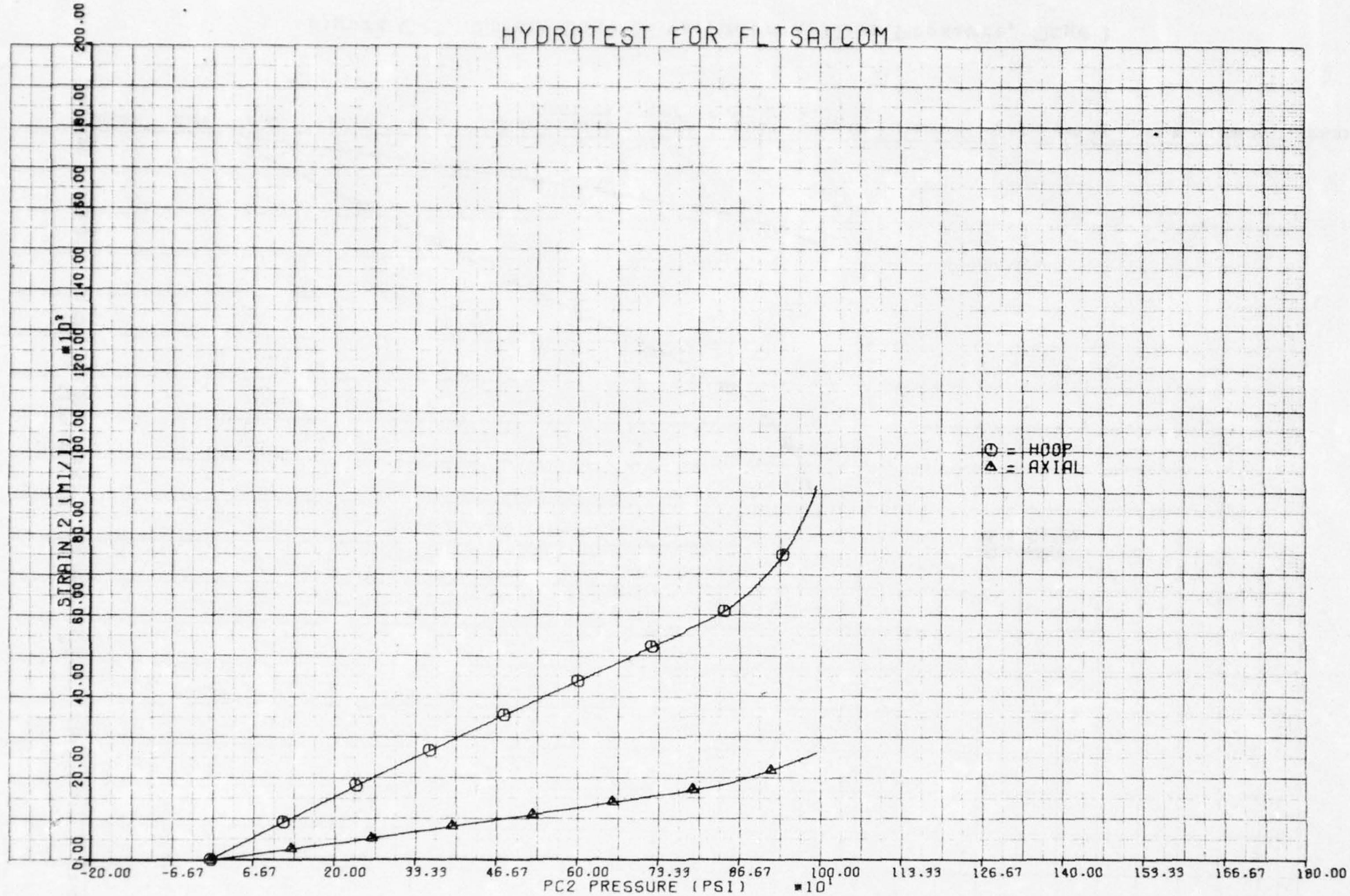


Figure C-4. Strain Gage #2 vs. Internal Case Pressure, Gage 2

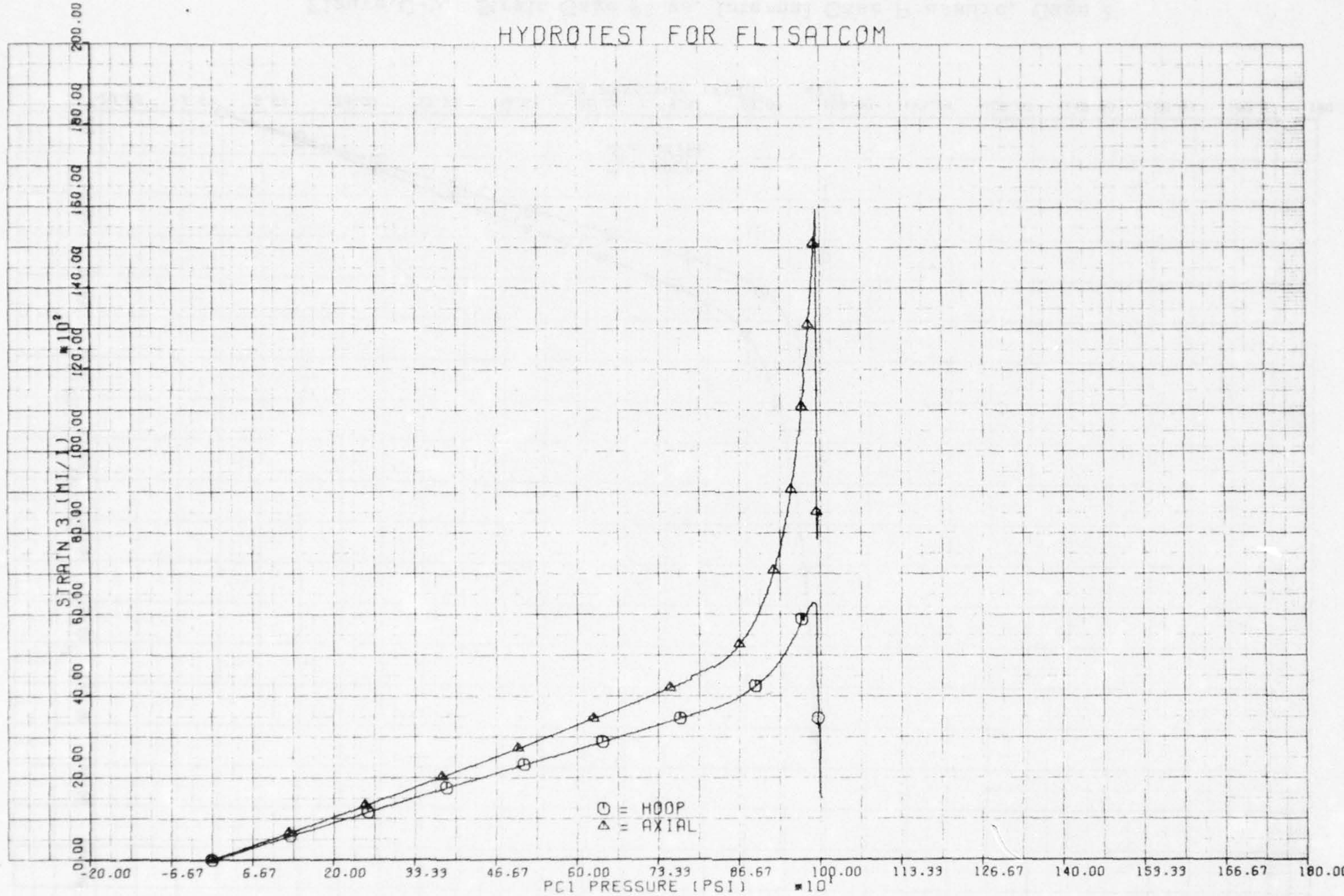


Figure C-5. Strain Gage #3 vs. Internal Case Pressure, Gage 1

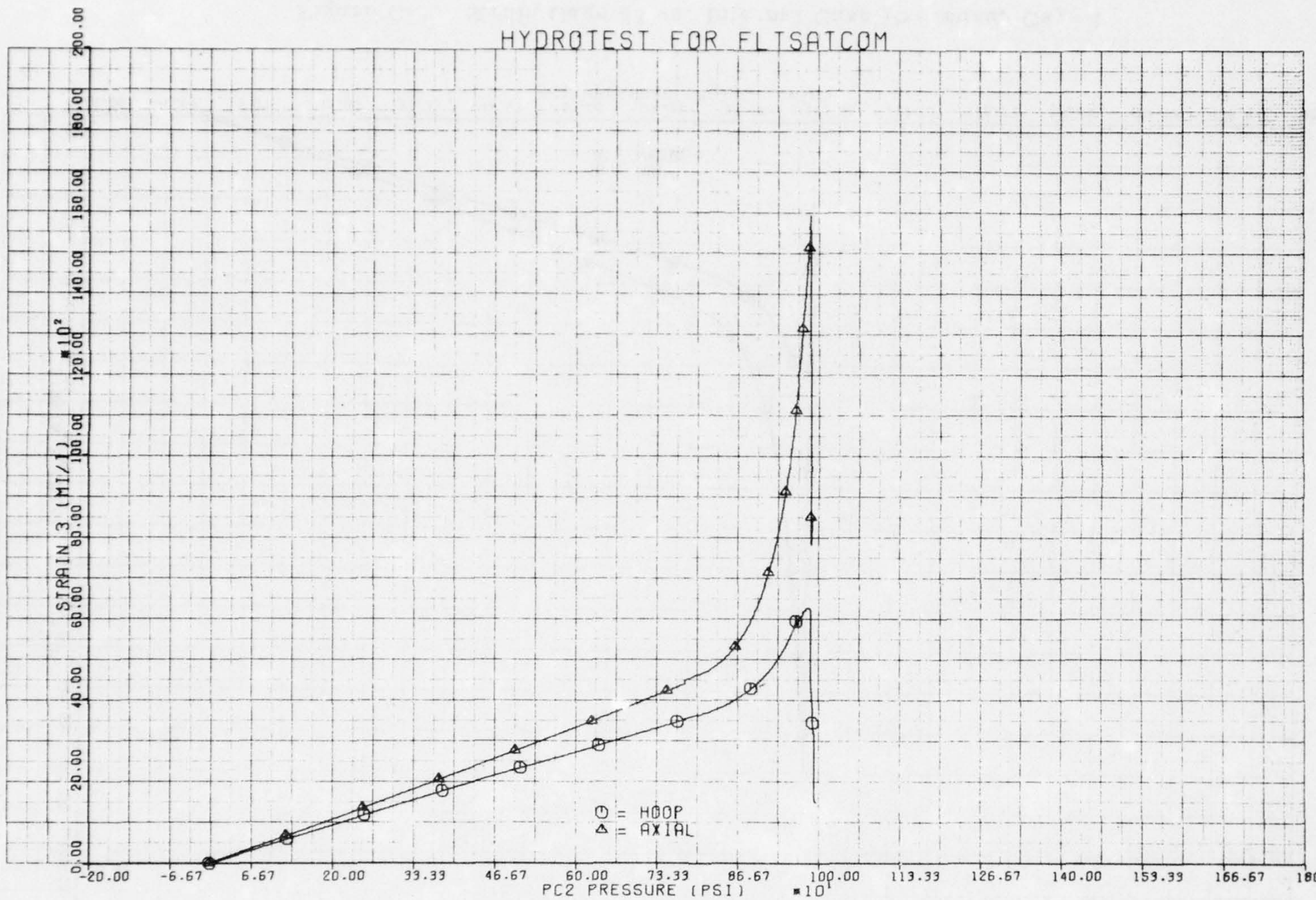


Figure C-6. Strain Gage #3 vs. Internal Case Pressure, Gage 2

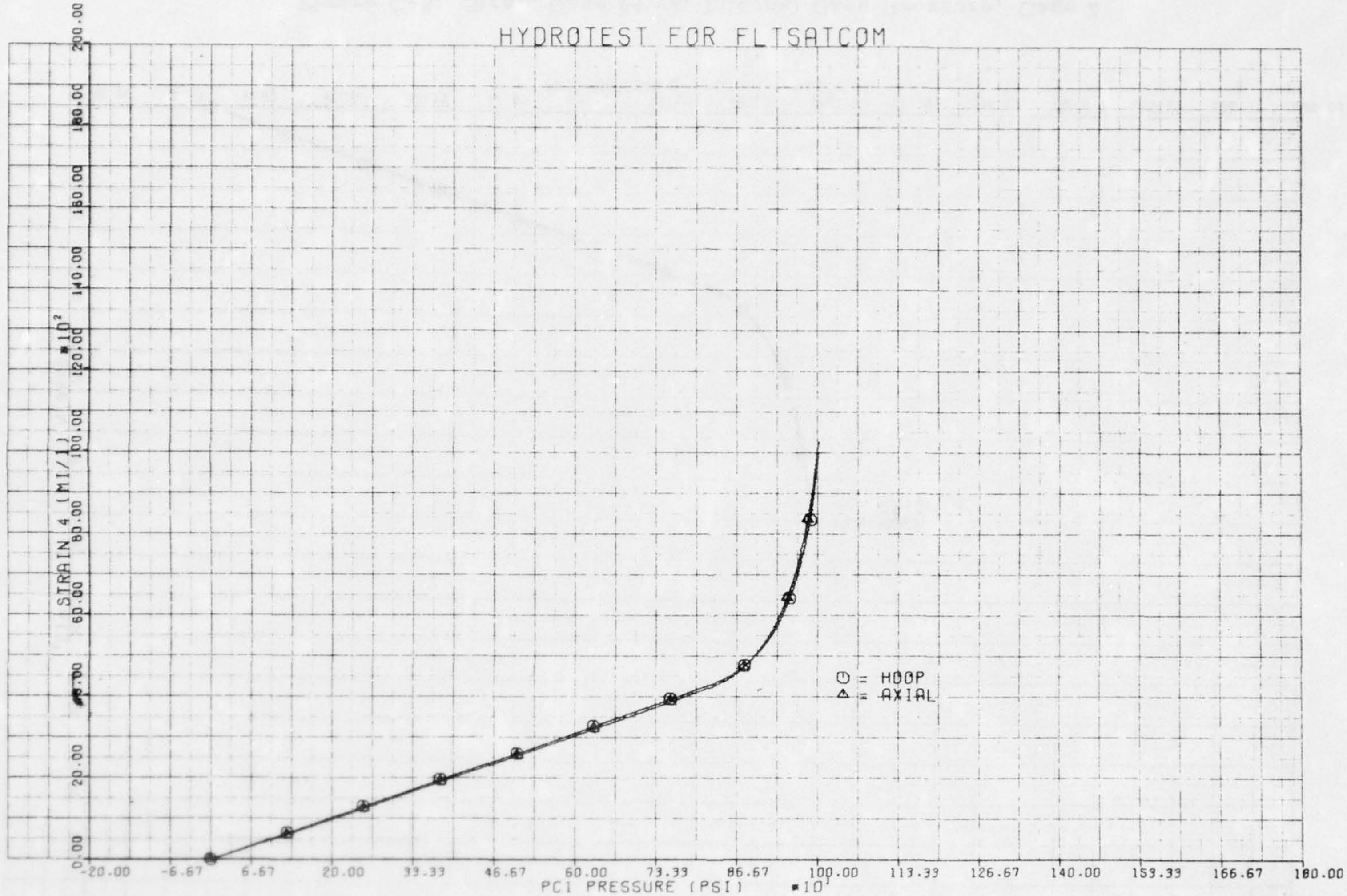


Figure C-7. Strain Gage #4 vs. Internal Case Pressure, Gage 1

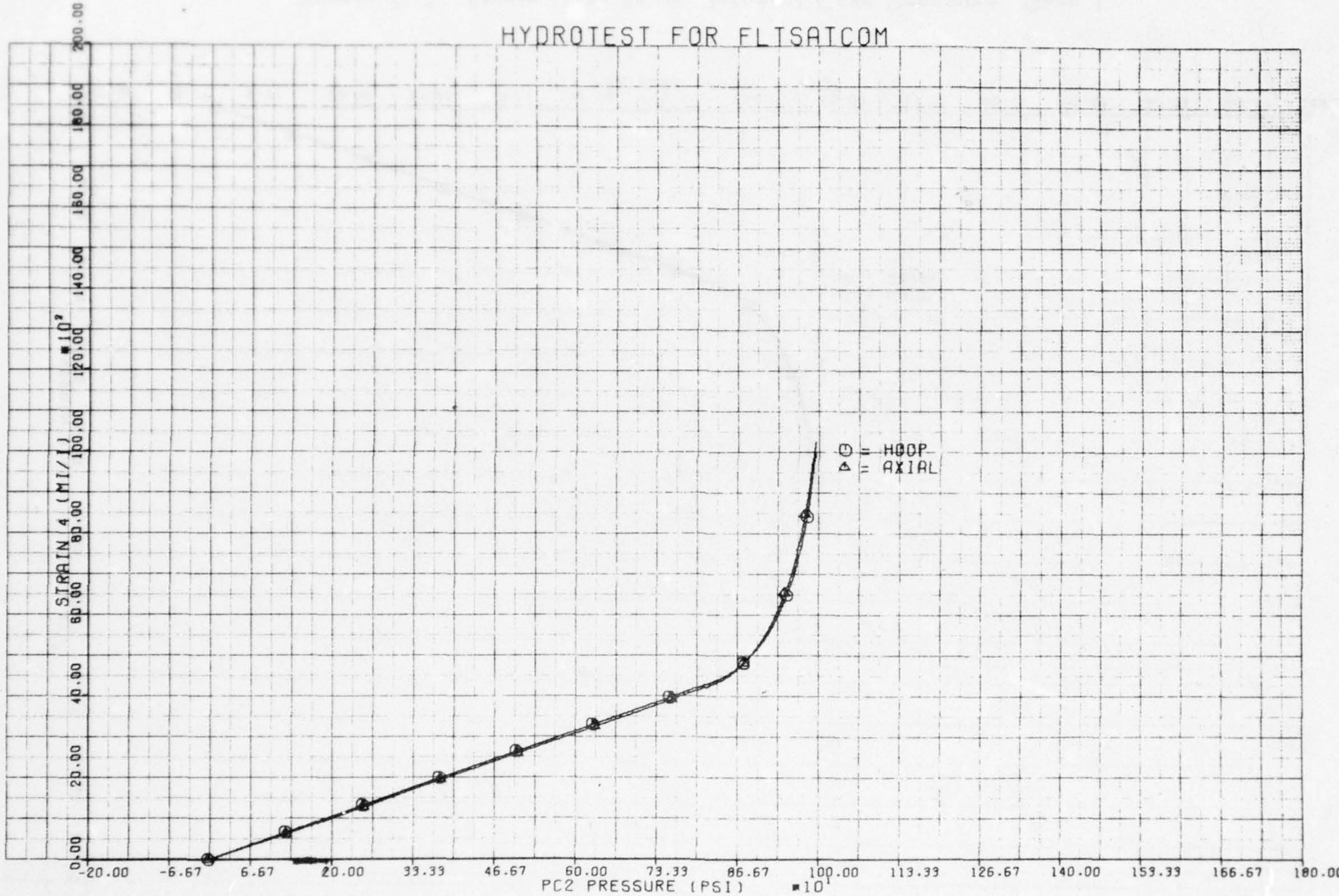


Figure C-8. Strain Gage #4 vs. Internal Case Pressure, Gage 2

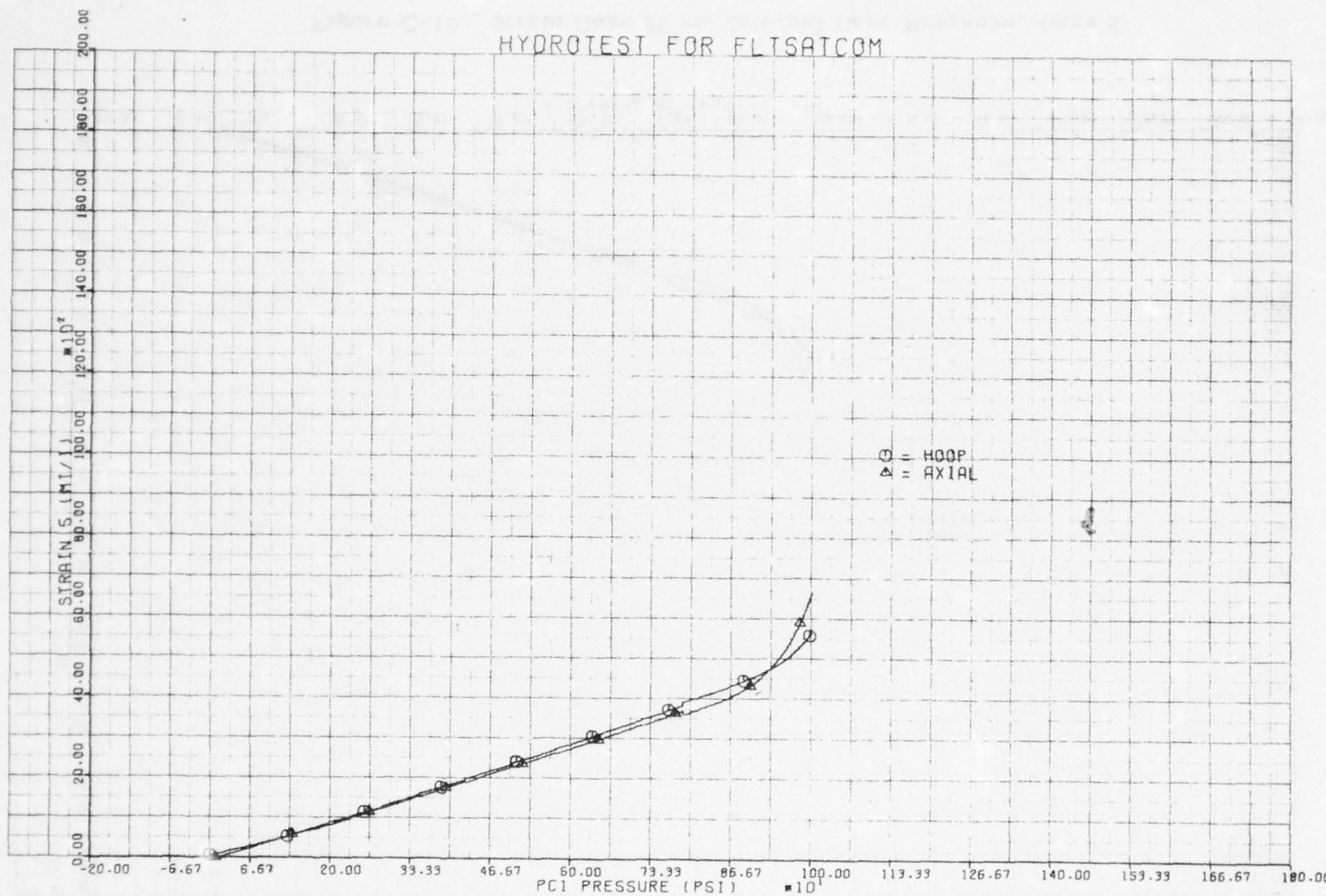


Figure C-9. Strain Gage #5 vs. Internal Case Pressure, Gage 1

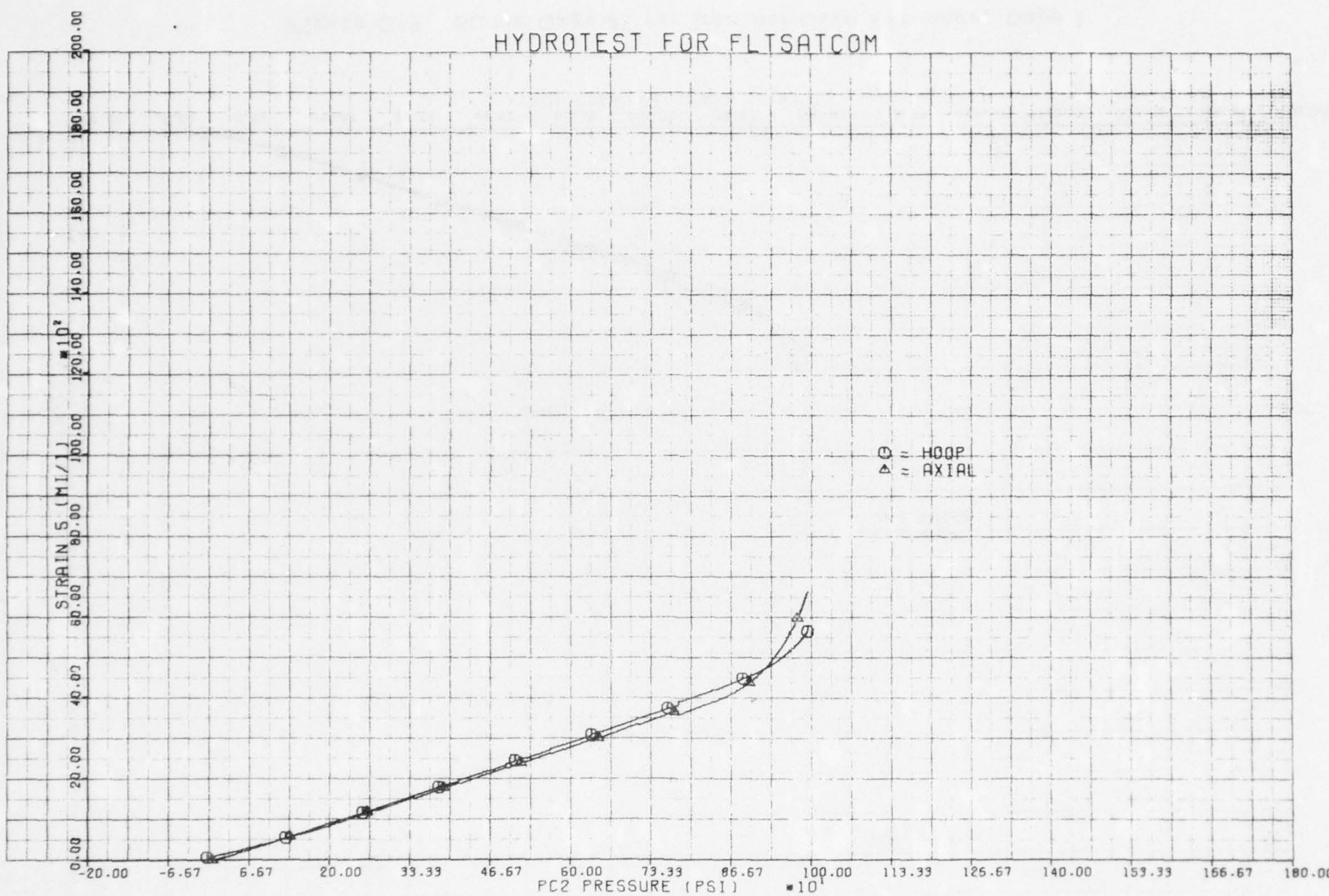


Figure C-10. Strain Gage #5 vs. Internal Case Pressure, Gage 2

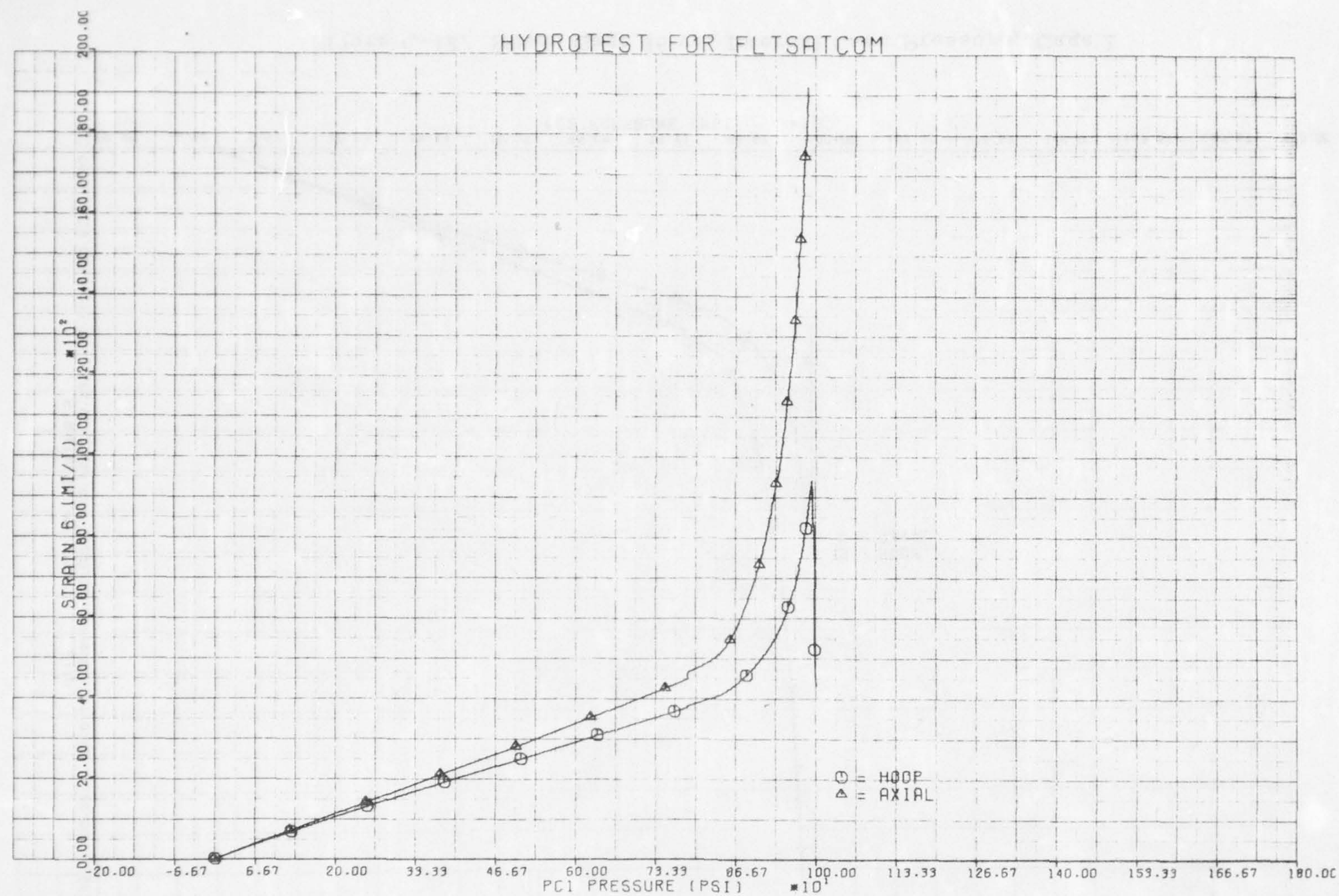


Figure C-11. Strain Gage #6 vs. Internal Case Pressure, Gage 1

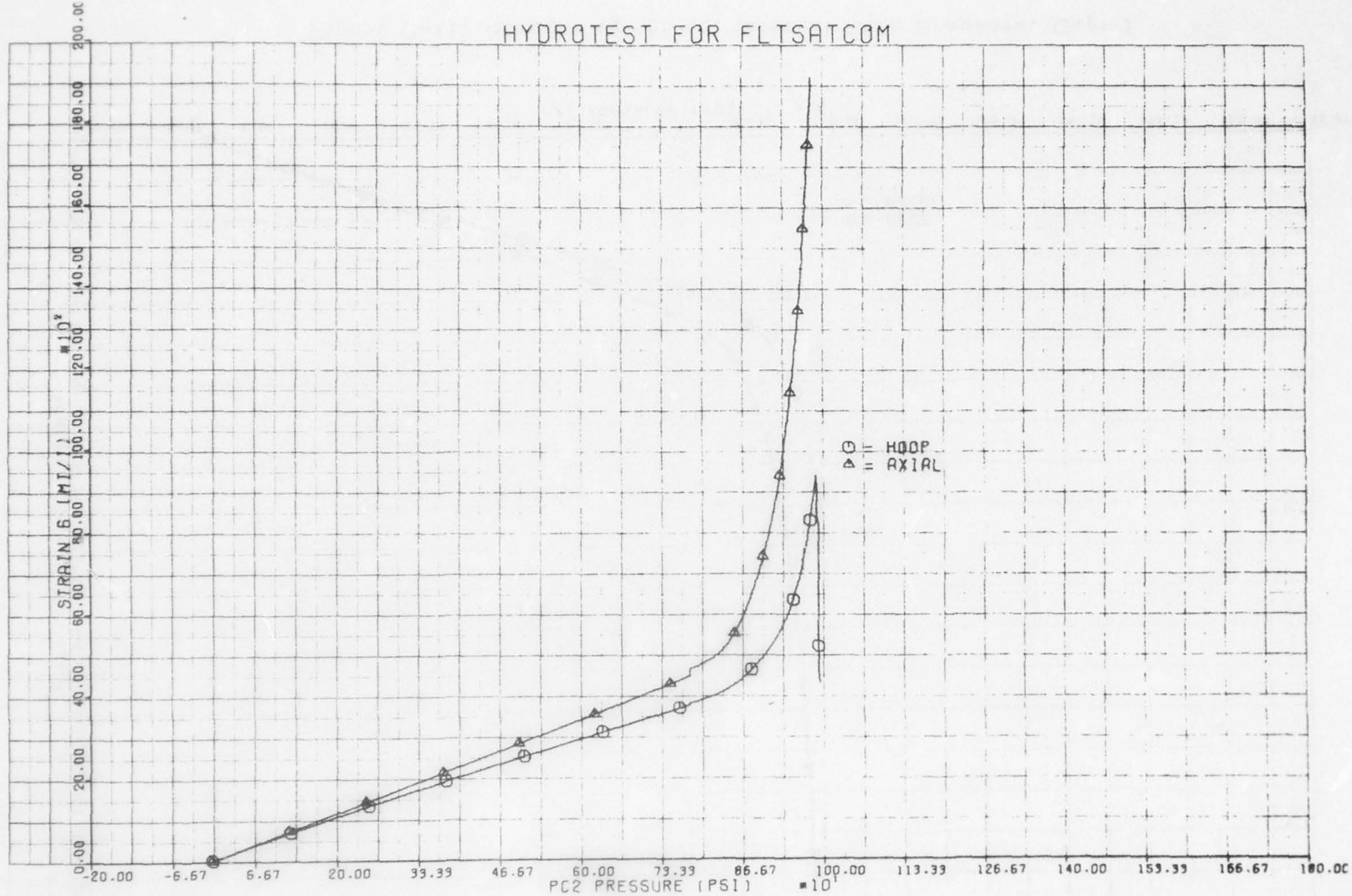


Figure C-12. Strain Gage #6 vs. Internal Case Pressure, Gage 2

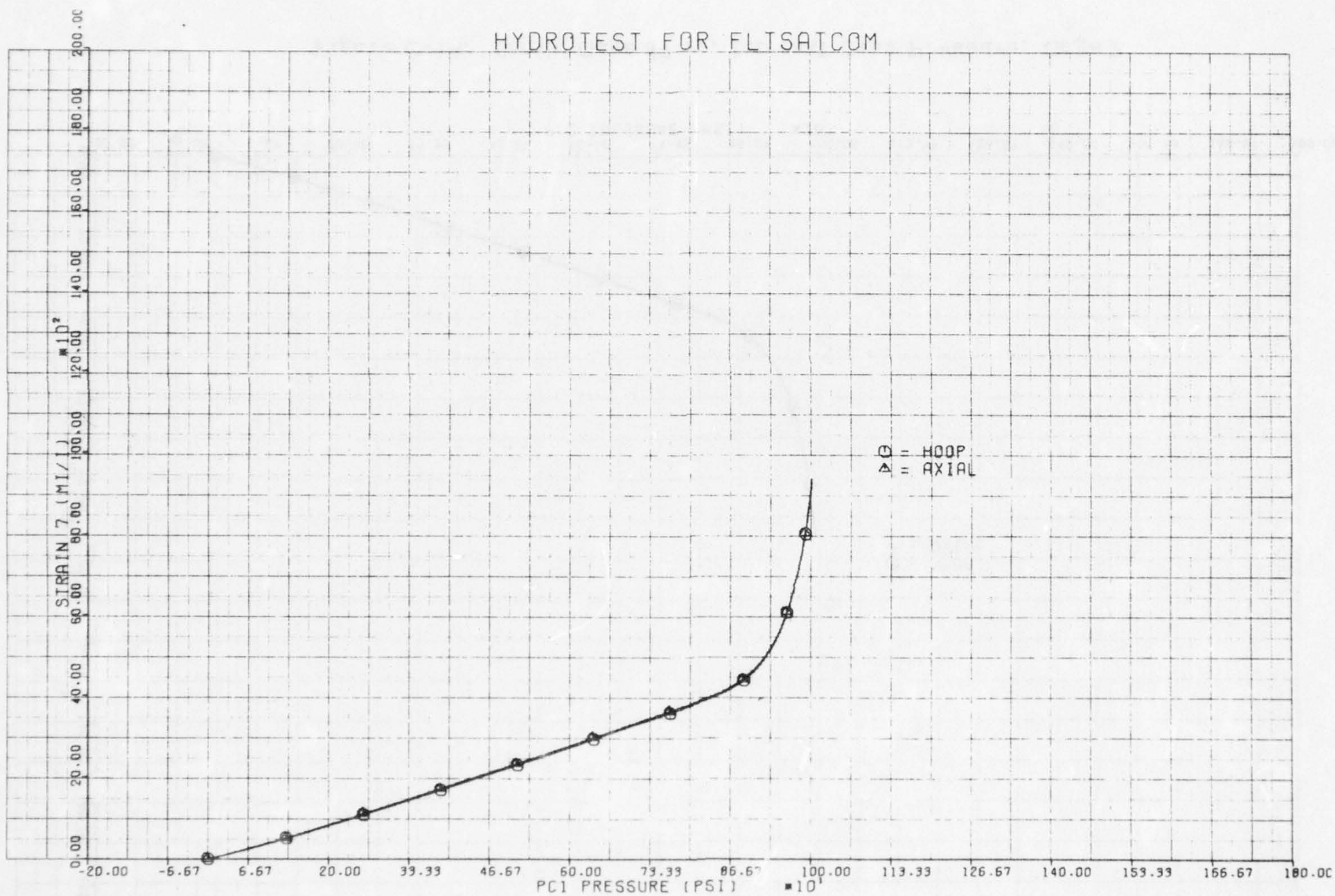


Figure C-13. Strain Gage #7 vs. Internal Case Pressure, Gage 1

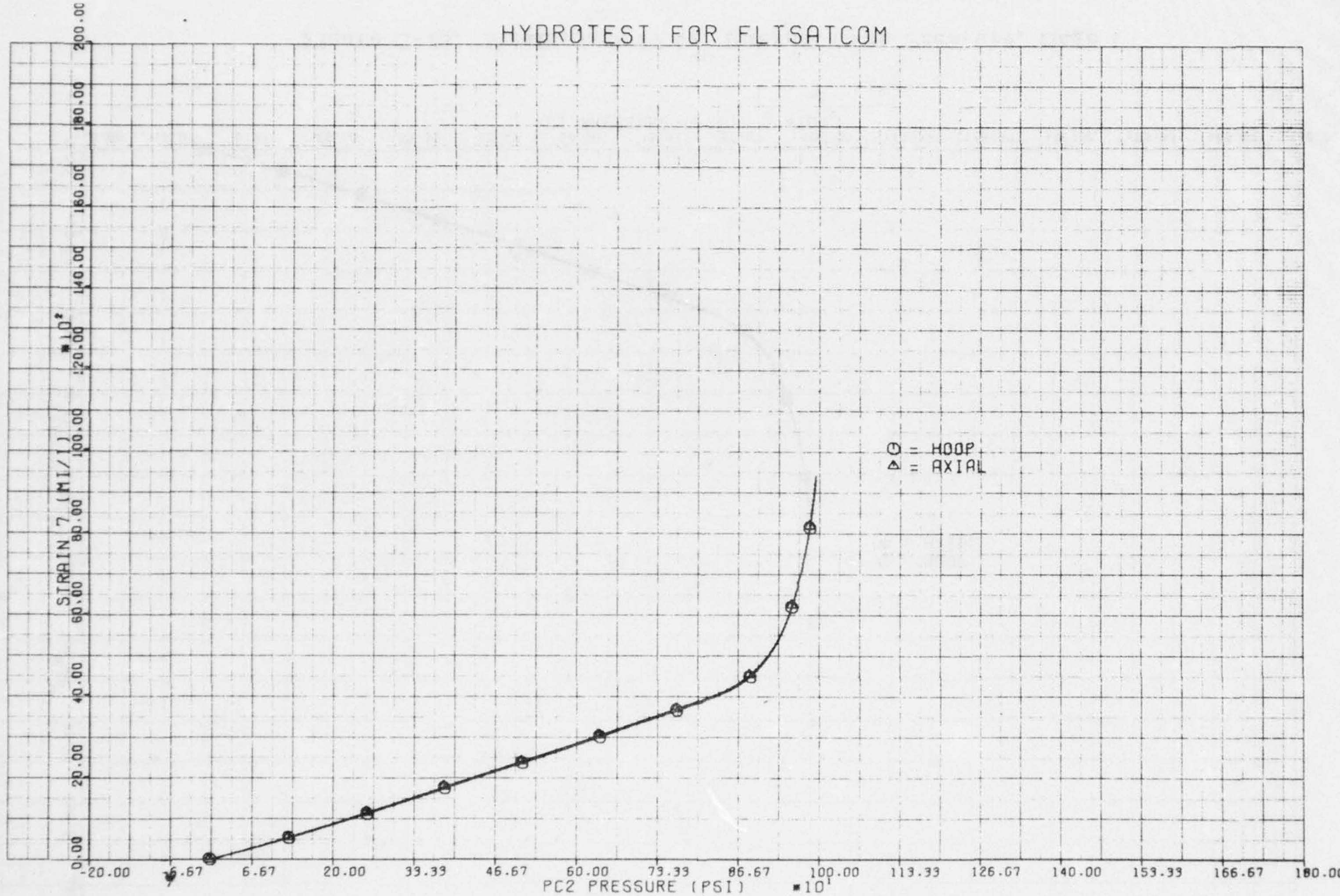


Figure C-14. Strain Gage #7 vs. Internal Case Pressure, Gage 2

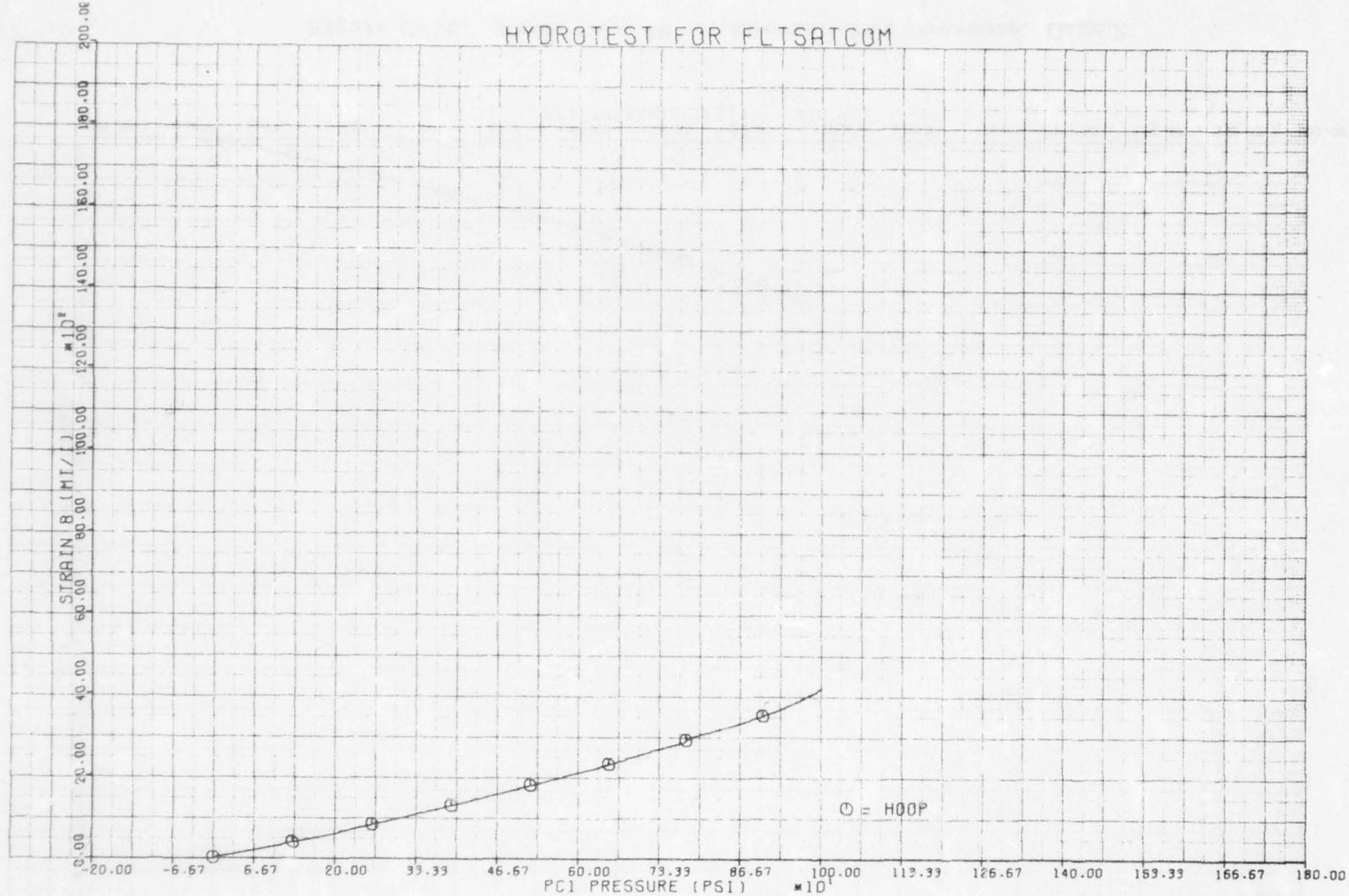


Figure C-15. Strain Gage #8 vs. Internal Case Pressure, Gage 1

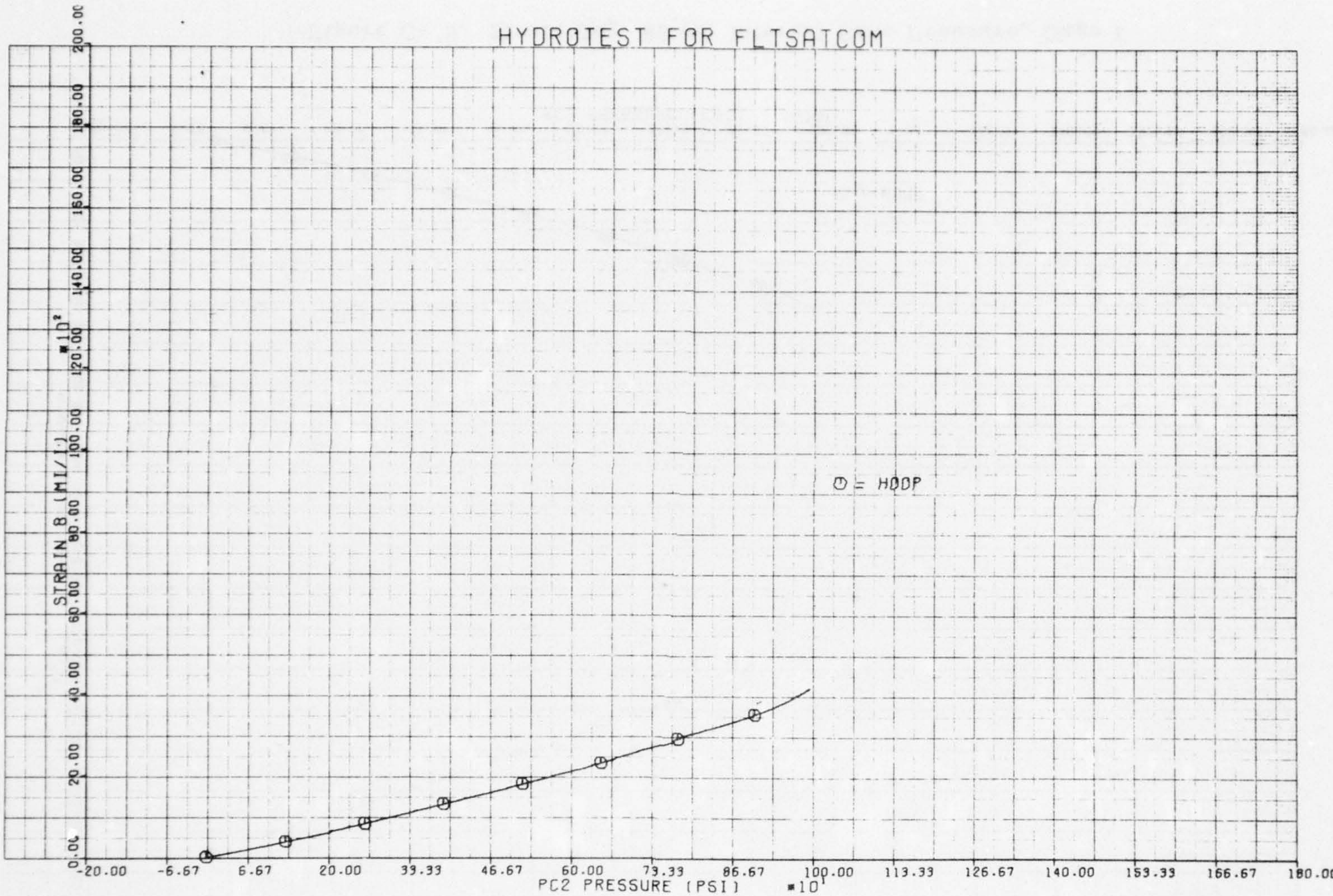


Figure C-16. Strain Gage #8 vs. Internal Case Pressure, Gage 2

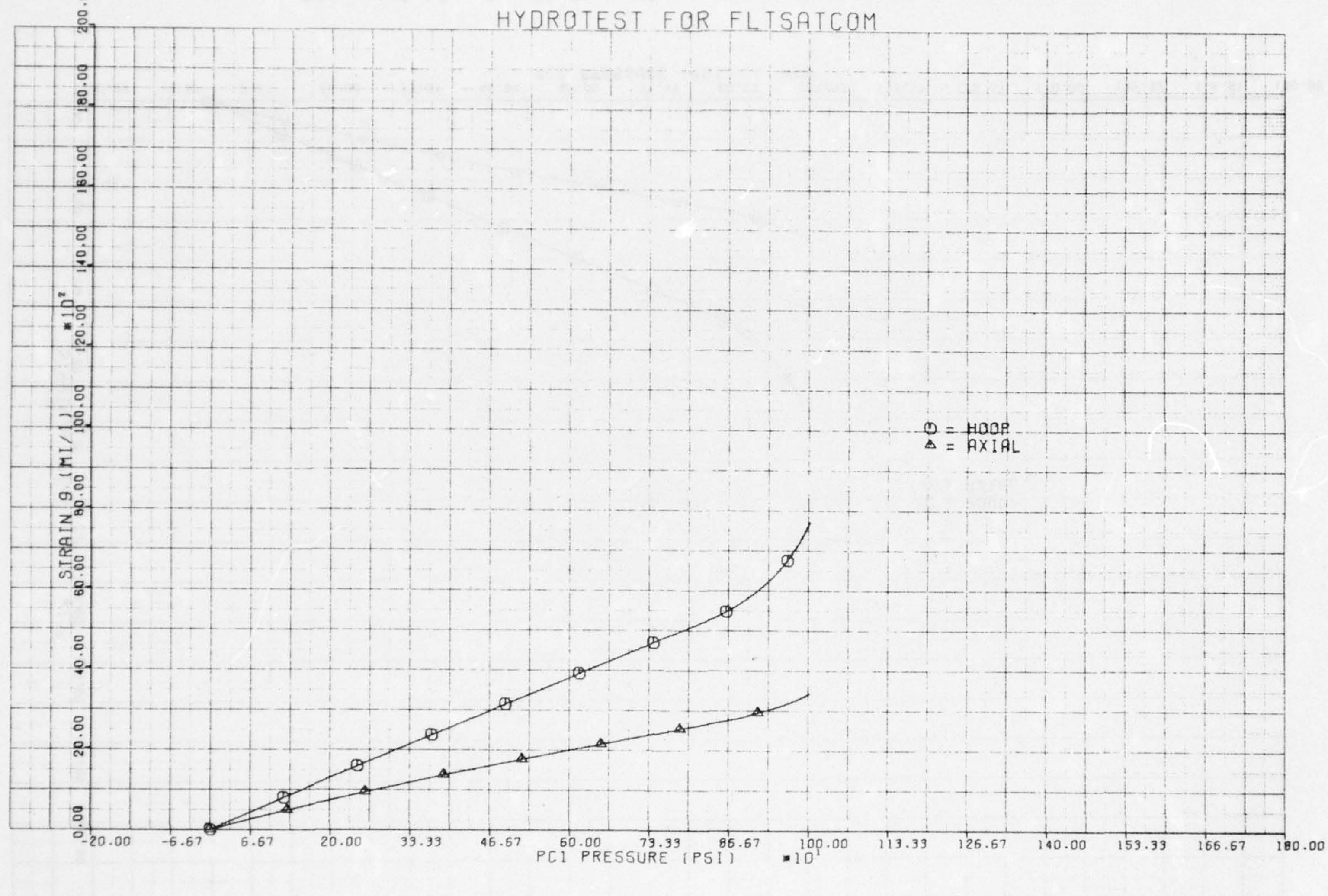


Figure C-17. Strain Gage #9 vs. Internal Case Pressure, Gage 1

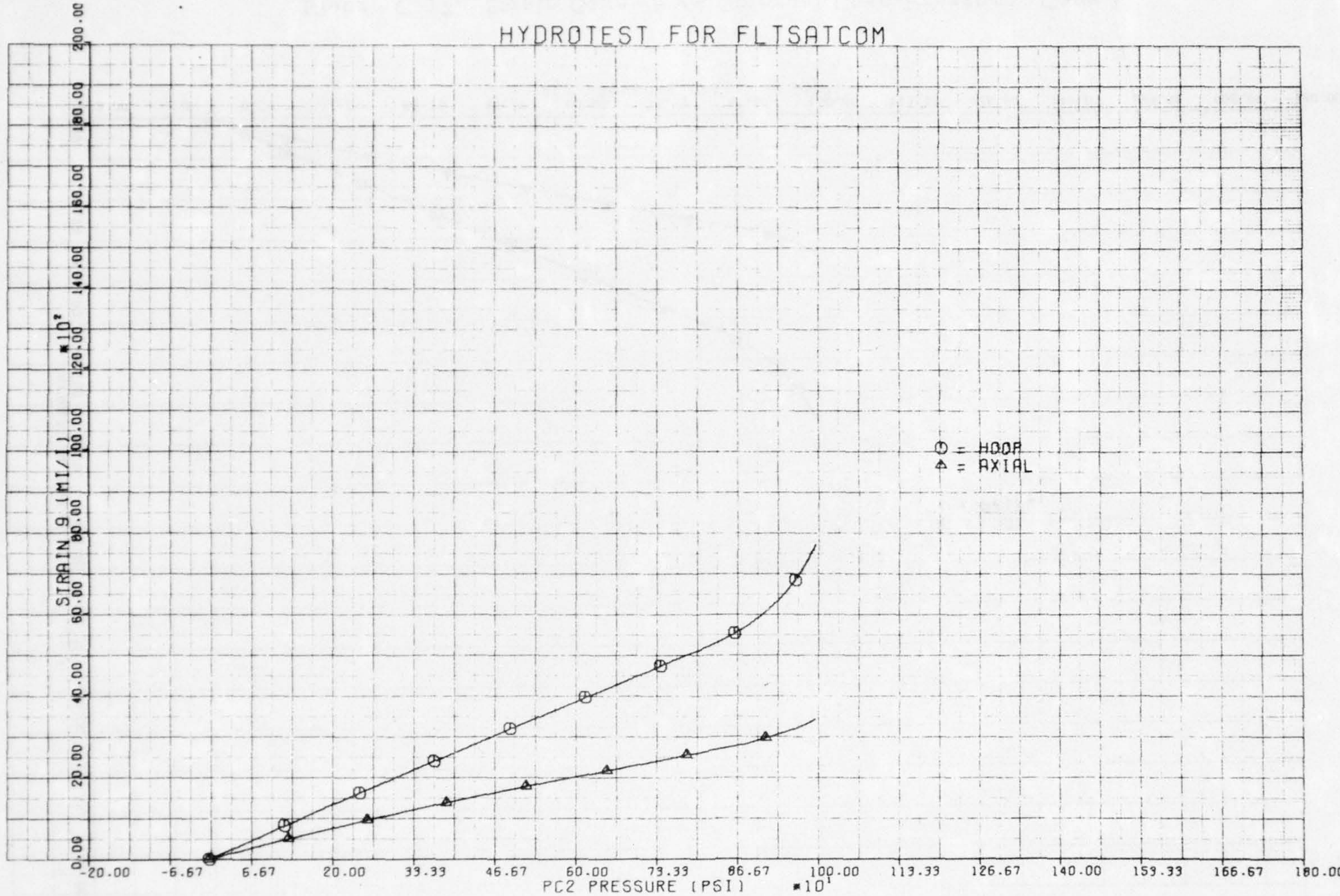


Figure C-18. Strain Gage #9 vs. Internal Case Pressure, Gage 2

APPENDIX D

PRE- AND POST-TEST STILL PHOTOGRAPHS

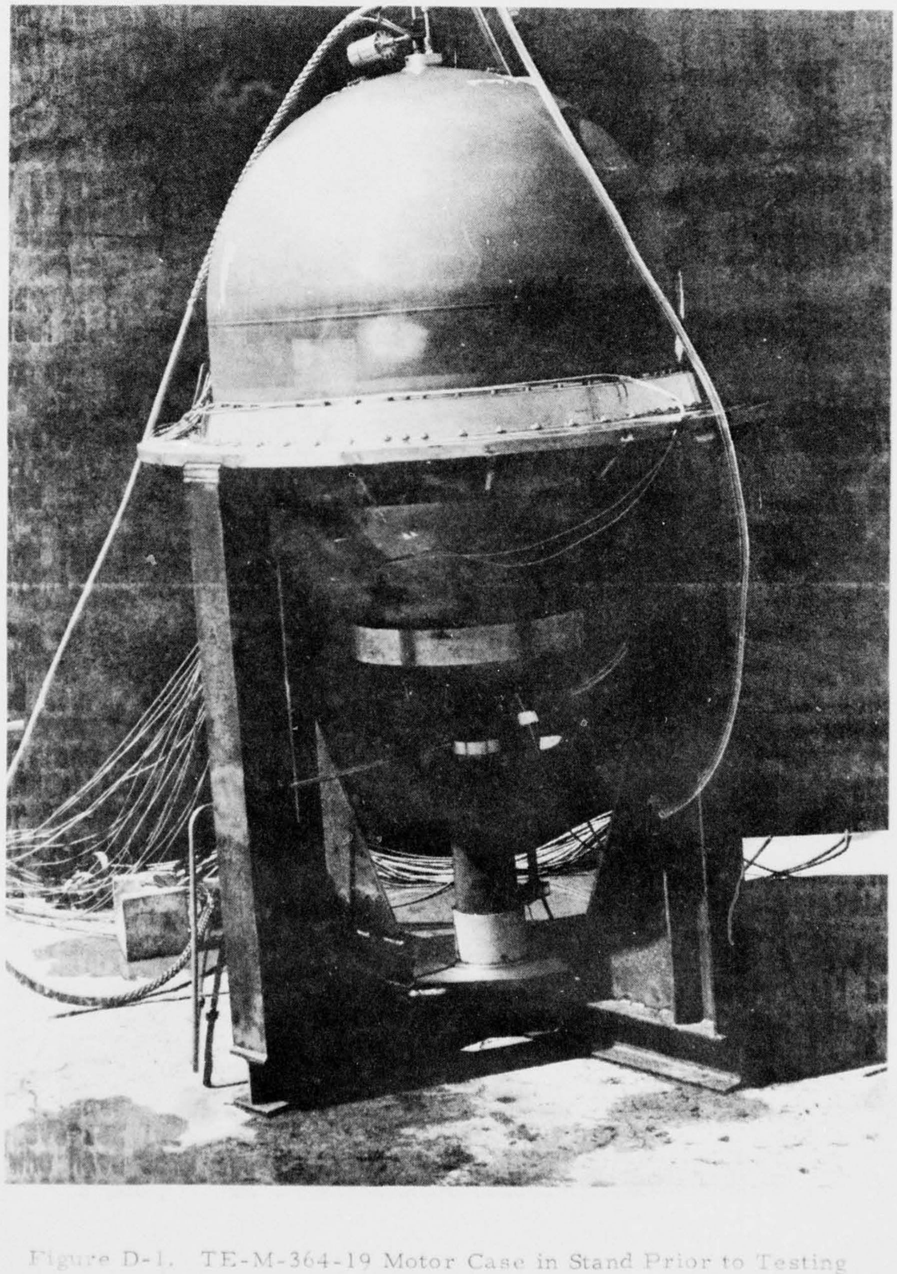

Figure D-1. TE-M-364-19 Motor Case in Stand Prior to Testing

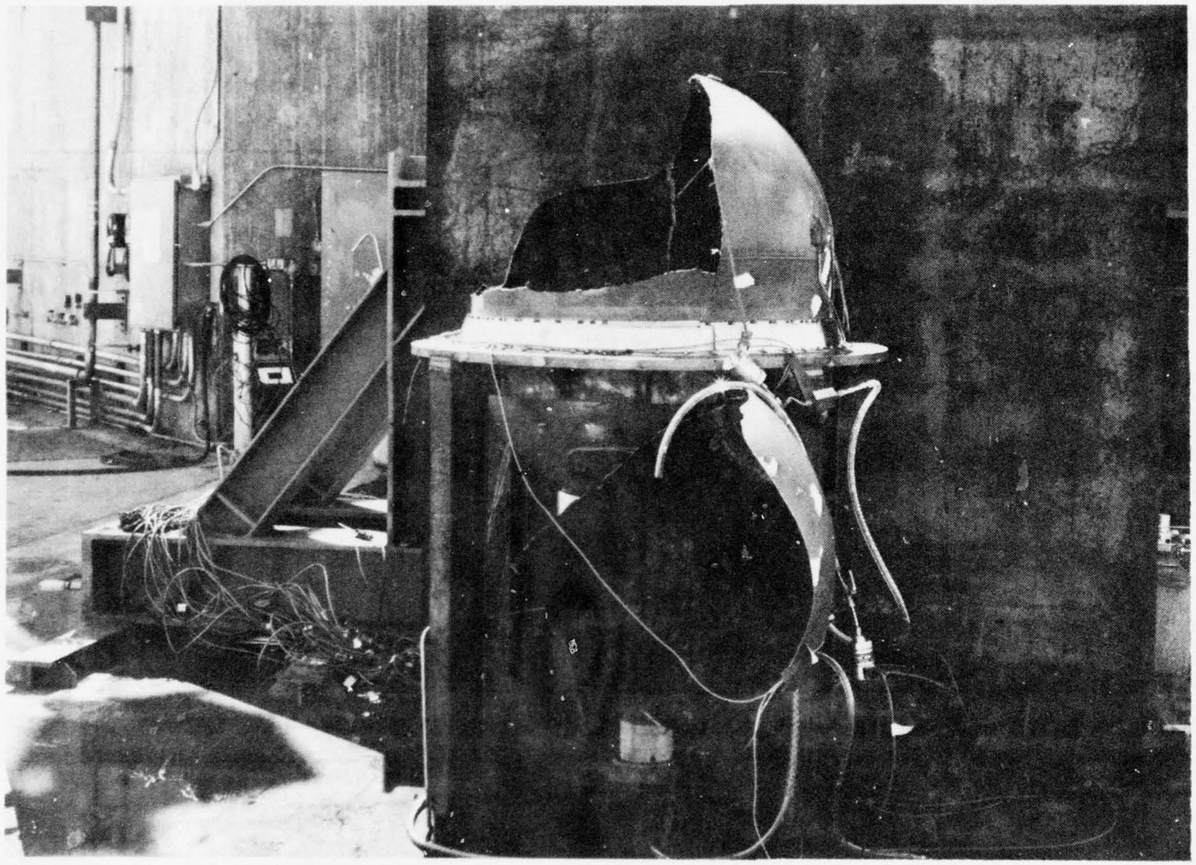

Figure D-2. TE-M-364-19 Motor Case in Stand After Testing